

**FINAL**

**PHASE I RFI/RI  
ENVIRONMENTAL EVALUATION  
WORK PLAN**

**ROCKY FLATS PLANT**

**WOMAN CREEK PRIORITY DRAINAGE  
(Operable Unit No. 5)**

**U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden, Colorado**

**ENVIRONMENTAL RESTORATION PROGRAM**

**June 1991**

**ADMIN RECORD**

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## **9.1 INTRODUCTION**

The objective of this Environmental Evaluation Work Plan is to provide a framework for addressing and quantifying the ecological effects to the biotic environment (plants, animals, microorganisms) from exposure to contaminants resulting from IHSSs within the Woman Creek Drainage, OU5. An ecosystem approach will be used as the basis for this environmental evaluation to ensure that ecological effects or endpoints (e.g., structural diversity, biomass, phenology, nutrient cycling, trophic structure) are addressed as well as populations and individuals that are more traditionally evaluated in a risk assessment approach (U.S. EPA 1989d). The ecosystem approach is comprehensive in that it initially addresses all ecosystem components, then progressively focuses on those aspects of the system potentially affected by contamination. The result of this process will be an evaluation of the nature and extent of contamination in biota, its relationship to abiotic sources, and the type and extent of adverse effects at the ecosystem, population, and individual levels of organization, as appropriate.

This plan is prepared in conformance with the requirements of current applicable legislation, including the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and follows the guidance for such studies as provided in the National Contingency Plan (NCP) and Environmental Protection Agency (EPA) documents for the conduct of Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Remedial Investigation (RFI/RI) activities. Specifically, the EPA guidance provided in Risk Assessment Guidance for Superfund, Vol. II, Environmental Evaluation Manual (U.S. EPA 1989c) is followed. Although a formal Natural Resource Damage Assessment (NRDA) process has not been initiated at Rocky Flats as of this time, this work plan was also designed to be consistent with the NRDA process to the maximum extent possible.

Determination of the effects on biota will be performed in conjunction with the human health risk assessment for OU5. Where appropriate, criteria necessary for performing the environmental evaluation will be developed in conjunction with human health risk assessments and environmental evaluations for all Rocky Flats Plant operable units (OUs). Information from the environmental evaluation will assist in determining the form, feasibility, and extent of remediation necessary for Woman Creek Drainage in accordance with CERCLA.

During preparation of this work plan, several documents were reviewed as part of an assessment of available information. These included the Final Environmental Impact Statement (EIS), Rocky Flats Plant (U.S. DOE 1980); Wetlands Assessment (EG&G 1990g); Draft Environmental Evaluation Work Plan for

OU2 (in RFI/RI Work Plan, EG&G 1991d); and the Final Phase III RFI/RI Work Plan, 881 Hillside Area (U.S. DOE 1990c) among others. Literature reviews will continue throughout the environmental evaluation. Review of this Draft Phase I RFI/RI Work Plan for OU5 and the Environmental Evaluation Work Plans for OU1 (U.S. DOE 1990c) and OU2 (EG&G 1991d) formed the basis for the establishment of the initial sampling locations presented in the OU5 Environmental Evaluation Field Sampling Plan (Subsection 9.3).

#### **9.1.1 Approach**

This plan presents a comprehensive approach to conducting the environmental evaluation at Woman Creek Drainage. This comprehensive approach is designed to ensure that all procedures to be performed are appropriate, necessary and sufficient to adequately characterize the nature and extent of environmental effects to biota under the "no action" scenario. The approach presented in this plan is adapted from the toxicity-based approach to the assessment of ecosystem effects (U.S. EPA 1989c, 1989d). The approach is based on standard risk assessment concepts whereby uncertainties concerning potential ecosystem effects are explicitly recognized and, where possible, quantified. The planned approach is also based, to the greatest extent possible, on providing objective estimates of ecological damage and the establishing a firm, causal relationship between contamination and ecological effects. To establish this relationship, the Work Plan focuses on the obtainment of three types of information:

- Chemical - Chemical analyses of appropriate media to establish the presence, concentrations, and variabilities of specific toxic compounds. This effort will be conducted under the RFI/RI abiotic sampling program.
- Ecological - Ecological surveys to characterize the condition of existing communities and establish whether any adverse effects have occurred.
- Toxicological - Toxicological and ecotoxicological testing to establish the link between adverse ecological effects and known contamination.

Without these three types of data, other potential causes of the observed effects on ecosystems unrelated to the presence of contamination, such as habitat alterations and natural variability, cannot be eliminated.

The ecological assessment scheme adopted for this project blends standard environmental and risk assessment methods with ecological and toxicological modeling to produce an integrated procedure for selecting contaminants of concern and indicator species, and for conducting an investigation of ecosystem effects resulting from contamination. As is recommended by EPA, this environmental

evaluation is not intended to be or to develop into a research-oriented project. The plan presented herein is designed to provide a focused investigation of potential contaminant effects on biota.

Each task of the environmental evaluation will be coordinated with RFI/RI activities at nearby operable units in order to avoid unnecessary duplication of effort and resources. Environmental evaluation planning is currently underway at two operable units in close proximity to OU5: OU1 (881 Hillside) and OU2 (903 Pad, Mound, and East Trenches Area). A coordinated approach with these operable units is necessary in order to account for contaminant migration into OU5. The environmental evaluation process has been divided into ten tasks. These tasks and their interrelationships are shown on Figure 9-1. The following is a brief description of each of these tasks. More detailed descriptions of each task are presented in Subsection 9.2.

#### Task 1: Preliminary Planning

Task 1 will focus on planning and coordination of the OU5 environmental evaluation with nearby OU1 and OU2 activities. Task 1 will include a determination of the scope of work and a definition of the study area. The Data Quality Objectives (DQO) process will be initiated in Task 1 according to EPA guidance (U.S. EPA 1989d), and procedures for monitoring and controlling data quality to the extent possible will be specified. Task 1 activities will include development of criteria for selection of contaminants of concern, key receptor species, and reference areas.

#### Task 2: Data Collection/Evaluation and Conceptual Model Development

Task 2 will include a review, evaluation, and summary of available chemical and ecological data and identification of data gaps. Based on these data, contaminants of concern will be identified based on their documented effects on key receptor species and/or other ecological endpoints. As part of the conceptual biota model development, a food web model will be constructed and preliminary exposure pathways will be identified. Results of these activities will be used to refine the ecological (Task 3) and ecotoxicological (Task 9) field investigation sampling designs.

#### Task 3: Ecological Field Investigation

Task 3 will include the preliminary field surveys, and an ecological field inventory to characterize OU5 biota and their trophic relationships and to note locations of obvious zones of chemical contamination. Brief field surveys will be conducted in the spring, summer, fall, and winter to obtain information on the occurrence, distribution, variability, and general abundance of key plant and animal species. Field inventories will be conducted in late spring and summer to obtain quantitative data on community composition in terrestrial and aquatic habitats. Samples collected as part of the activity will be saved for tissue analyses where contaminants of concern have been identified and sampling protocol are in

place. Task 3 will also include aquatic toxicity tests using Ceriodaphnia spp., and fathead minnows. As part of these activities, all collected field data will be reduced, evaluated, compared with, and integrated into the existing database to update knowledge of site conditions.

#### Task 4: Toxicity Assessment

Task 4 will entail compilation of toxicity literature and the toxicological assessment of potential adverse effects from contaminants of concern on key receptor species. This task will be performed in conjunction with the following Task 5.

#### Task 5: Exposure Assessment and Pathways Model

Task 5 will entail development of a site-specific pathways model based on the ecological field survey. This exposure-receptor pathways model will be used to evaluate the transport of contaminants at OU5 to biological receptors. The pathways model is based on a conceptual pathways approach (Fordham and Reagan 1991) and will provide an initial determination of the movement and distribution of contaminants, likely interactions among ecosystem components, and expected ecological effects. It is anticipated that this approach will be coordinated with the efforts of investigators working in other operable units to avoid duplication of effort, to collect comparable data, and to provide a consistent assessment of contaminant effects.

#### Task 6: Preliminary Contamination Characterization

Task 6 will provide a characterization of the threat or risk of OU5 contaminants to receptor populations and habitats. Determinations will be made as to the magnitude of the effects of contamination on OU5 biota. The actual or potential effects of contamination on ecological endpoints (e.g., species diversity, food web structure, productivity) will also be addressed. Depending on DQOs and the quality of data collected, the contamination characterization will be expressed qualitatively, quantitatively, or a combination of the two. Task 6 may include the preliminary derivation of remediation criteria. Development of these criteria will entail consideration of federal and Colorado laws and regulations pertaining to preservation and protection of natural resources that are Applicable or Relevant and Appropriate Requirements (ARARs) (see Section 3.0). Information from ARARs, toxicological assessments, and the pathways model will be used to develop criteria that address biological resource protection.

#### Task 7: Uncertainty Analysis

Task 7 includes the identification of assumptions and the evaluation of uncertainty in the environmental risk assessment analysis. Task 7 will include the identification of data needs to calibrate/validate the pathways model developed in Task 5.

#### Task 8: Planning

Task 8 will entail the development of additional DQOs with respect to the conduct of Task 9, Ecotoxicological Field Investigation. DQOs to be achieved by such sampling will be defined according to EPA guidance (U.S. EPA 1989d). Scoping and design of Task 9 field studies will be based initially on the outcome of Tasks 1 through 3. Field sampling will only be performed where acceptance criteria for demonstrating injury to a biological resource will be satisfied in accordance with regulations under the Natural Resource Damage Assessment Rule [40 CFR Subtitle A Section 11.62 (f)] and the accompanying Type B Technical Information Document (U.S. DOI 1987).

#### Task 9: Ecotoxicological Field Investigation

Task 9 will include tissue analysis studies and any additional ecotoxicological field investigations. Samples collected in Task 3 field studies will be used wherever possible (e.g., when contaminants of concern have been identified and sampling protocols are in place); new samples will be collected if necessary. The need for measuring additional population endpoints through reproductive success, enzyme inhibition, microbial respiration, or other ecotoxicological studies will be evaluated based on the Task 3 preliminary ecological risk assessment. Selection of the target analytes, species, and tissues will be based on the determination of which contaminants are likely to be present in sufficient concentrations, quantities, and locations as to be detected in biota. Selection of these specific criteria will be developed in consultation with EPA and the State. All necessary federal and state permits will be obtained prior to any destructive sampling or collecting.

#### Task 10: Environmental Evaluation Report

Task 10 will provide a final characterization of contamination in biota at OU5. Results from the Task 9 ecotoxicological field investigations will be used to evaluate ecosystem effects. Information on site environmental characteristics and contaminants, characterization of effects, remediation criteria, conclusions, uncertainty analysis, and limitations of the assessment will be summarized into the Environmental Evaluation Report.

Each of the preceding tasks is described in further detail in Subsection 9.2. A suggested outline for the Environmental Evaluation Report is presented in Subsection 9.2.11. The field sampling plan presented

in Subsection 9.3 addresses both the Task 3 ecological investigation and the Task 9 ecotoxicological field investigations. A tentative outline for the environmental evaluation report is presented in Subsection 9.2.11.

### **9.1.2 OU5 Contamination**

A number of chemicals are suspected to be present in OU5 soils and surface water at levels above background, as described in Section 2.0 of the Phase I RFI/RI Work Plan (Table 9-1). Preliminary reviews of available data show some chemicals (organics, metals, and radionuclides) in surface water to be above detection levels (Tables 2-5, 2-6, and 9-1). Which of these levels are above background is currently being evaluated as part of the RFI/RI effort. Most of the contaminants are likely to impact biota if present at sufficient concentrations. The following subsections present a discussion of which of these chemicals are likely to be of paramount concern at OU5, given their toxic nature. Actual selection of contaminants of concern to biota will take place in Task 2 after a more detailed analysis of potential adverse effects and review of available toxicological literature. Further comparisons of site data to the recent Background Geochemical Characterization Report (EG&G 1990c) to determine above background levels will also be made as part of the RFI/RI investigation.

#### **9.1.2.1 Metals**

##### **Terrestrial Ecosystems**

Heavy metals are the most commonly evaluated environmental contaminants in biomonitoring studies of terrestrial ecosystems. Studies on heavy metals are of several types: (1) reports of metal concentrations in animals from only one location, (2) correlations of tissue concentrations with environmental concentrations, (3) monitoring a site through time, (4) concentrations in animals collected along a gradient of pollution, and (5) comparisons of concentrations in animals from reference and contaminated sites or sites where contamination is suspected. These studies generally provide information on background concentrations of contaminants and correlations of tissue concentrations with environmental concentrations. Data from the Talmage and Walton (1990) study are available for most heavy metals for a variety of mammal species and lower trophic levels. Data from Talmage and Walton (1990) and other available studies on heavy metals effects on biota will be reviewed as part of the Task 2 effort and compared to OU5 data as appropriate.

Several of the heavy metals detected in aquatic ecosystems at OU5 are phytotoxic and are known to bioaccumulate and biomagnify in terrestrial and aquatic ecosystems. Bioaccumulation, the process by which chemicals are taken up by organisms directly or through consumption of food containing the chemicals, is documented for arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, and selenium. Biomagnification, or the process by which tissue concentrations of chemicals increase as the

TABLE 9-1

CHEMICALS DETECTED AT OU5\*

ORIGINAL LANDFILL (IHSS 115)

Soil:

Organics: petroleum distillates, 1,1,1-trichloroethane, dichloromethane, benzene, carbon tetrachloride and trichloroethane

Metals: beryllium, lead and chromium

Radionuclides: uranium

ASH PITS, INCINERATOR AND CONCRETE WASH PAD (IHSSs 133.1-133.6)

Soil:

Radionuclides: uranium

Metals: unknown

Ponds C-1 AND C-2 (IHSSs 142.10 and 142.11)

Surface Water:

Organics: phenol, di-n-butyl phthalate

Metals: manganese, zinc, aluminum, mercury and strontium

Radionuclides: americium-241, cesium-137, plutonium-239, strontium-90, tritium, uranium-233/234, uranium 235, uranium-238 and radium-226

Anions: sulfide/sulfate and nitrate/nitrite

Sediments:

data on metals, organics and anions not yet available

Radionuclides: plutonium

WOMAN CREEK DRAINAGE

Surface Water:

Organics: data not yet available

Metals: aluminum, strontium, manganese, barium, lead, lithium, zinc, mercury, molybdenum, chromium, copper, tin, arsenic, beryllium, cobalt and nickel

Radionuclides: americium-241, cesium-137, plutonium-239, strontium-90, uranium-233/234, uranium-235, uranium-238, tritium and radium-226

Anions: sulfate and nitrate/nitrite

Sediments:

Data not yet available

\*Not determined whether or not these levels are above background.

Source: Section 2.0, Tables 2-2 through 2-6, Phase I RFI/RI Work Plan for OU5.

chemical passes up through two or more trophic levels, is documented from soil to plants for beryllium, cadmium, chromium, copper, lead, mercury, and selenium. In herbivores, biomagnification occurs for antimony, arsenic, cadmium, chromium, copper, lead, mercury and selenium. In terrestrial carnivores, mercury and cadmium are known to biomagnify. Any, if not all, of these metals are likely to become contaminants of concern in the OU5 environmental evaluation depending on historical usage, concentrations detected in soils, and potential uptake by biological receptors at OU5.

### Aquatic Ecosystems

EPA has established ambient water quality criteria (AWQC) to be protective of the environment (U.S. EPA 1986b). Specifically, these criteria represent the maximum allowable water concentrations consistent with the protection of aquatic wildlife. One rationale for establishing criteria protective of aquatic life is that aquatic organisms and plants are important in food chains to higher life forms. In addition, their direct dependence on the aquatic environment results in constant contact with the water and the organisms are therefore likely to assimilate any contaminants. One EPA objective in establishing AWQC was to determine chemical concentrations that would not be directly harmful to aquatic organisms and plants and would not present a hazard to higher life forms due to any biomagnification of individual chemical substances.

Of the maximum levels of metals detected in surface water at OU5 (see Section 2.0, Tables 2-5 and 2-6), eight are of immediate interest in the evaluation of aquatic ecosystems given their presence at levels above federal surface water quality standards (Table 9-2). These are aluminum, barium, chromium, copper, lead, manganese, mercury, and zinc. Of these metals, chromium, copper, lead, mercury, and zinc are likely to be contaminants of concern because of their potential to biomagnify. Brief summaries of information from the AWQC document (U.S. EPA 1986b) and other available toxicological literature on these metals of likely concern are presented in the following text. Similar toxicity profiles will be evaluated against site-specific concentrations data in the selection of contaminants of concern and key receptor species. The occurrence of these metals at elevated levels does not necessarily imply that they are available for assimilation in all organisms or that they transfer to successive trophic levels. The potential for adverse effects to occur is dependent of a number of physicochemical factors including: (1) physiological and ecological characteristics of the organism; (2) forms of dissolved trace metals; (3) forms of trace metals in ingested solids; and (4) chemical and physical characteristics of water (Jenne and Luoma 1977). Each of these factors will be considered in the evaluation of potential adverse environmental effects at OU5.

TABLE 9-2

COMPARISON OF MAXIMUM OU5 METALS CONCENTRATIONS<sup>(a)</sup> TO FEDERAL SURFACE WATER STANDARDS<sup>(b)</sup>

|            | ALUMINUM                                                                         | ARSENIC                                                               | BARIUM                     | BERYLLIUM                                                              | CADMIUM                                              | CHROMIUM                                                                                    | COBALT                                                                             |
|------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------|------------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|            | SDWA MCL (Sec.)<br>50 to 200 µg/l*                                               | SDWA MCL<br>50 µg/l                                                   | SDWA MCL<br>1000 µg/l      | CWA AWQC<br>(Acute) 130 µg/l<br>(Chronic) 5.3 µg/l                     | CWA AWQC<br>(Acute) 3.9 µg/l<br>(Chronic) 1.1 µg/l   | SDWA MCL<br>100 µg/l**                                                                      |                                                                                    |
| <b>OU5</b> |                                                                                  |                                                                       |                            |                                                                        |                                                      |                                                                                             |                                                                                    |
| POND C-1   | 1,420 µg/l                                                                       | N.D.                                                                  | N.D.                       | N.D.                                                                   | N.D.                                                 | N.D.                                                                                        | N.D.                                                                               |
| POND C-2   | N.D.                                                                             | N.D.                                                                  | N.D.                       | N.D.                                                                   | N.D.                                                 | N.D.                                                                                        | N.D.                                                                               |
| SW-32      | 24,800 µg/l                                                                      | N.D.                                                                  | 387 µg/l                   | N.D.                                                                   | N.D.                                                 | 222 µg/l                                                                                    | N.D.                                                                               |
| SW-36      | 99,600 µg/l                                                                      | 9.4 µg/l                                                              | 1,470 µg/l                 | 7.8 µg/l                                                               | N.D.                                                 | 118 µg/l                                                                                    | 61.8 µg/l                                                                          |
| SW-39      | N.D.                                                                             | N.D.                                                                  | N.D.                       | N.D.                                                                   | N.D.                                                 | N.D.                                                                                        | N.D.                                                                               |
|            |                                                                                  |                                                                       |                            |                                                                        |                                                      |                                                                                             |                                                                                    |
|            | COPPER                                                                           | LEAD                                                                  | MANGANESE                  | MERCURY                                                                | NICKEL                                               | SELENIUM                                                                                    | ZINC                                                                               |
|            | CWA AWQC<br>(Acute) 18 µg/l<br>(Chronic) 12 µg/l<br>SDWA MCL (Sec.)<br>1000 µg/l | CWA AWQC<br>(Acute) 82 µg/l<br>(Chronic) 3.2 µg/l<br>SDWA MCL 50 µg/l | SDWA MCL<br>50 µg/l (Sec.) | CWA AWQC<br>(Acute) 2.4 µg/l<br>(Chronic) .012 µg/l<br>SDWA MCL 2 µg/l | CWA AWQC<br>(Acute) 1,400 µg/l<br>(Chronic) 160 µg/l | CWA AWQC<br>(Acute) 260 µg/l<br>(Chronic) 36 µg/l<br>SDWA MCL 10 µg/l<br>SDWA MCL 50 µg/l** | CWA AWQC<br>(Acute) 120 µg/l<br>(Chronic) 110 µg/l<br>SDWA MCL 5000 µg/l<br>(Sec.) |
| <b>OU5</b> |                                                                                  |                                                                       |                            |                                                                        |                                                      |                                                                                             |                                                                                    |
| POND C-1   | N.D.                                                                             | N.D.                                                                  | 599 µg/l                   | 1.8 µg/l                                                               | N.D.                                                 | N.D.                                                                                        | 228 µg/l                                                                           |
| POND C-2   | N.D.                                                                             | N.D.                                                                  | 2,520 µg/l                 | 0.3 µg/l                                                               | N.D.                                                 | N.D.                                                                                        | 358 µg/l                                                                           |
| SW-32      | 25.2 µg/l                                                                        | 24.8 µg/l                                                             | 622 µg/l                   | 0.3 µg/l                                                               | N.D.                                                 | N.D.                                                                                        | 201 µg/l                                                                           |
| SW-36      | 122 µg/l                                                                         | 84.0 µg/l                                                             | 2,140 µg/l                 | 1.1 µg/l                                                               | 105 µg/l                                             | N.D.                                                                                        | 413 µg/l                                                                           |
| SW-39      | N.D.                                                                             | N.D.                                                                  | 58.5 µg/l                  | 3 µg/l                                                                 | N.D.                                                 | N.D.                                                                                        | 22.2 µg/l                                                                          |

SDWA = Safe Drinking Water Act

MCL = Maximum Contaminant Level

AWQC = Ambient Water Quality Criteria

N.D. = Not Detected

(a) Tables 2-2 through 2-6, Phase I RFI/RI Work Plan for OU5

(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990)

(c) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, and 143, Final Rule effective July 30, 1992.

### Chromium(VI)

The toxicity of chromium is largely due to its oxidizing action in its hexavalent state (as chromic oxide, chromate, or dichromate) and its easy permeation of biologic membranes (NRC 1974). Acute toxicity values for chromium(VI) are available for freshwater animal species in 27 genera; these values range from 23.07  $\mu\text{g/l}$  for a cladoceran to 1,870,000  $\mu\text{g/l}$  for a stonefly. These species include a wide variety of animals that perform a wide spectrum of ecological functions. Daphnids are especially sensitive. The few data that are available indicate that the acute toxicity of chromium(VI) decreases as hardness and pH increase.

The chronic value for both rainbow trout and brook trout is 264.6  $\mu\text{g/l}$ ; while the chronic value for fathead minnow is 1,987  $\mu\text{g/l}$ . Chronic tests using chinook salmon show a reduction in growth at low concentrations of 16  $\mu\text{g/l}$ . Chronic values in soft water for daphnids range from <2.5 to 40  $\mu\text{g/l}$  and acute-chronic ratios range from 1.130 to >9.680. Green algae are quite sensitive to chromium(VI). The bioconcentration factor (BCF) for rainbow trout is less than 3.

### Copper

The toxicity of copper to aquatic organisms is due primarily to the cupric ( $\text{Cu}^{2+}$ ) ion and possibly to some of the hydroxy complexes. Concentrations of copper ranging from 1 to 8,000  $\mu\text{g/l}$  inhibit growth of various aquatic plant species. Sensitivities for aquatic invertebrates and fish are similar to those for plants. Acute toxicity data are available for species in 41 genera of freshwater animals. At a hardness of 50  $\text{mg/l}$ , the genera range in sensitivity from 16.74  $\mu\text{g/l}$  for Ptychocheilus to 10,240  $\mu\text{g/l}$  for Acroneuria. Acute toxicity generally decreases as water hardness increases. Additional data for several species indicate that toxicity also decreases with increases in alkalinity and total organic carbon. Chronic values are available for 15 freshwater fish species and range from 3.873  $\mu\text{g/l}$  for brook trout to 60.36  $\mu\text{g/l}$  for northern pike. Fish and invertebrate species seem to be equally sensitive to the chronic toxicity of copper.

Protection of animal species appears to offer adequate protection of plants. Copper does not appear to bioconcentrate very much in the edible portion of freshwater aquatic species. Many animals have some ability to cope with excess copper through excretion (Rand and Petrocelli 1985). In animals where copper is not excreted, copper will accumulate in tissues, especially in the liver.

### Lead

The acute toxicity of lead to several species of freshwater animals has been shown to decrease as the hardness of water increases. At a hardness of 50  $\text{mg/l}$ , the acute sensitivities range from 142.5  $\mu\text{g/l}$  for an amphipod to 235,900  $\mu\text{g/l}$  for a midge. Data on the chronic effects of lead on freshwater animals

are available for two fish and two invertebrate species. The lowest and highest available chronic values (12.26 and 128.1  $\mu\text{g/l}$ ) are both for a cladoceran, but in soft and hard water respectively. Freshwater algae are affected by concentrations of lead above 500  $\mu\text{g/l}$ , based on data for four species. BCFs are available for four invertebrate and two fish species and range from 42 to 1,700.

Several enzymes are sensitive to lead at very low concentrations. Lead strongly inhibits several ATPases, lipoamide dehydrogenase, and aminolevulinic acid dehydratase, which is involved in the synthesis of heme (Rand and Petrocelli 1985). In vertebrate animals, lead poisoning is characterized by neurological defects, kidney dysfunction, and anemia.

### Mercury

Mercury is toxic to all forms of biota in aquatic ecosystems, although many factors (e.g., alkalinity, pH, and temperature) influence toxicity. The toxic action of mercury in plants and animals appears to involve cell membranes and their permeability. In mammals, early subacute poisoning generally has a neurological manifestation (Rand and Petrocelli 1985). Data are available on the acute toxicity of mercury(II) to 28 genera of freshwater animals. Acute values for invertebrate species range from 2.2  $\mu\text{g/l}$  for Daphnia pulex to 2,000  $\mu\text{g/l}$  for three insects. Acute values for fish range from 30  $\mu\text{g/l}$  for the guppy to 1,000  $\mu\text{g/l}$  for Mozambique tilapia. Few data are available for various organomercury compounds and mercurous nitrate, which are 4 to 31 times more acutely toxic than mercury(II).

Available chronic data indicate that methylmercury is the most chronically toxic of the tested mercury compounds. Tests on methylmercury with Daphnia magna and brook trout show chronic values less than 0.07  $\mu\text{g/l}$ . For mercury(II), the chronic value for Daphnia magna is about 1.1  $\mu\text{g/l}$  and the acute-chronic ratio (median lethal concentration sufficient to produce short term effects/concentration producing effects after long term exposure) is 4.5. In both a life-cycle test and an early life-stage test on mercuric chloride with the fathead minnow, the chronic value was less than 0.26  $\mu\text{g/l}$  and the acute-chronic ratio was over 600.

Freshwater plants show a wide range of sensitivities to mercury, but the most sensitive plants appear to be less sensitive than the most sensitive freshwater animals to both mercury(II) and methylmercury. A BCF of 4,994 is available for mercury(II); BCFs for methylmercury range from 4,000 to 85,000.

### Zinc

The levels of dietary zinc at which toxic effects are evident depend markedly on the concentration ratio of zinc to copper (Rand and Petrocelli 1985). Zinc is also a metabolic antagonist of cadmium, so that high zinc intakes in animals afford some protection against cadmium exposure. Acute toxicity values are available for 43 species of freshwater animals. Data indicate that acute toxicity generally decreases

as hardness increases. When adjusted to a hardness of 50 mg/l, sensitivities range from 50.70 µg/l for Ceriodaphnia reticulata to 88,960 µg/l for a damselfly. Additional data indicate that toxicity increases as temperature increases. Chronic toxicity data are available for nine freshwater species. Chronic values for two invertebrates range from 46.73 µg/l for Daphnia magna to >5,243 µg/l for the caddisfly, Clistoronia magnificia. Chronic values for seven fish species range from 36.41 µg/l for flagfish, Jordanella floridae, to 854.7 µg/l for the brook trout, Salvelinus fontinalis. The sensitivity range of freshwater plants is greater than that for animals. Growth of the alga, Selenastrum capricornutum, is inhibited by 30 µg/l; however, 4-day EC50s (median effective concentration sufficient to produce some adverse response to 50% of test organisms) for several other species of green algae, exceed 200,000 µg/l. Zinc bioaccumulates in freshwater animal tissues at 51 to 1,130 times the water concentration.

#### **9.1.2.2 Radionuclides**

Basic ecological research on radionuclides in the environment has a 40-year history resulting in sophisticated models for identification and prediction of the movement and concentration of specific radionuclides. The same is true for effects on humans resulting from exposure to both external and internal sources of radiation. Most of the scientific literature concerning radioecology has resulted from interaction between DOE operated facilities and nearby universities.

The following discussion is a brief summary of the radionuclide literature reviewed. In general, transuranics tend to bind in the soils and sediments and have limited availability to biota. Bioaccumulation or concentration factors routinely are low between trophic levels. Data from Little et al. (1980) from the Rocky Flats Plant site indicate that radionuclide inventories (and thus radiation doses) in vertebrate populations are well below levels known to elicit effects. Based on the following cursory literature review, it seems unlikely that at the low dose levels reported, sufficient sensitive methods exist to distinguish adverse biological response from background "noise" (chance fluctuations due to climate, weather, human disturbance, etc.) at the Rocky Flats Plant Site.

#### **Terrestrial Ecosystems**

Historically, the principal reason for determining BCFs for terrestrial biota was to calculate the internal radiation dose to higher trophic levels at an equilibrium body burden from radionuclides assimilated from foodstuffs. For the most part, BCFs for mammals have been collected from fallout studies under widely varied habitat conditions (arctic, desert, temperature zone, and laboratory), and, consequently, there are few consistent generalizations. Concentration factors for cesium-137 typically show an increase from plants to mammalian herbivores as well as increases at the higher trophic levels. Ninefold increases in cesium-137 through the plant → mule deer → cougar food-chain were demonstrated in the work done by Pendleton et al. (1965). Also an increase of approximately 2- to 5- fold at each link in the lichen → caribou → wolf food-chain has been reported by Hanson et al. (1967).

Less comprehensive data are available for the other radionuclides, but it is evident that not all radionuclides are concentrated in food-chains and that different food-chains may exhibit markedly different concentration patterns for the same nuclide. The strontium-90 BCF for the plant → herbivore chain ranges from 0.02 to 8.4; while the BCFs for tritium, cobalt-60 and iodine-131 are less than 1.0, with the exception of 2.4 for seed → water → quail for cobalt-60 movement (Auerbach 1973).

There have been few field studies on the comparative uptake of actinides (transuranics) by biota from contaminated soils. Uranium, thorium, and plutonium transfer in terrestrial food-chains has not been well studied because of the difficulty and expense of analyzing these elements at low levels in biota and the frequent high degree of variation in field data that complicates statistical comparisons between different actinides. Field studies that have been conducted on soil-plant-animal transfer suggest that bioaccumulation of these elements does not occur. The Hakonson (1975) study of actinide levels in soils, plants, and animals indicates that, at the Trinity Site, residual plutonium was approximately 10 times lower in small rodents than in the corresponding grass samples. This same trend has been noted in other studies as well (Garten and Daklman 1978, Garten et al. 1981). Bly and Whicker (1978) found that the mean ratio of plutonium-239 in arthropods to plutonium-239 in 0 to 3 cm soil at Rocky Flats Plant was  $1.9 \times 10^{-3}$ .

Little et al. (1980) conducted a comprehensive study in the grassland ecosystem around Rocky Flats. The overall conclusions mirror the previously mentioned works in that plutonium was not accumulated up through the food-chain. Additionally, the body burdens of biota were significantly lower than required to elicit a biological or ecological effect.

Most studies of radiosensitivities of soil fungal populations have been performed in the laboratory. Studies on the effects of irradiation of natural populations in the field have been rare and have suffered from inadequate controls (Stotsky and Mortenson 1959, Stanovick et al. 1961)

A study by Edwards (1969), revealed distinct differences in radiosensitivities of various microarthropod groups, but all were killed at levels much lower than those lethal to microflora. Oribatid mites, the most radiation-resistant microarthropods, were killed by 200 kilorads. Auerbach et al. (1957) found that, with lower radiation doses, a lag effect exists in growth rates in certain microarthropods, such as Collembola. Cawse (1969) noted that bacteria are the most tolerant to radiation up to about 2.5 megarads. Fungi are resistant up to about 1 megarad (Johnson and Osborne 1964).

Fraley and Whicker (1973) found native shortgrass plains vegetation to be very resistant to chronic gamma radiation at exposure rates varying from 0.01 to 650 Roentgen/hour (R/hr usually expressed as roentgen equivalent man-rem). One of the most resistant species was Lepidium densiflorum, which became dominant at exposure rates of 12 to 28 R/hr and was able to germinate, develop, and complete seed set at exposure rates greater than 28 R/hr. The level of radiation exposure in their study is many

orders of magnitude greater than any encountered in the environment around facilities such as Rocky Flats.

A long-term project was initiated in 1968 at Oak Ridge National Laboratory (Styron et al. 1975) to assess effects of mixed beta and gamma radiation from simulated fallout on a grassland ecosystem. Extensive statistical analyses of data on numbers of individuals collected for each of 76 arthropod and 2 molluscan taxa have identified no lasting significant changes in similarity or species diversity of experimental versus control communities as the result of the long-term irradiation at low doses rates. Natural fluctuations in community dynamics obscured any possible radiation effects.

Mammal species and populations exhibit a similar resistance to chronic low-level exposures and even acute exposures required in excess of 100 rads to elicit reproductive, hemopoietic, or survivorship responses (Kitchings 1978).

### **Aquatic Ecosystems**

Aquatic food-chain dynamics are similar to those previously described for terrestrial ones. On the whole, the actinides have no known biological function and do not show an affinity for muscle in higher trophic level organisms (Poston and Klopfer 1988). In a study conducted at the Savannah River Plant by Whicker et al. (1990), aquatic macrophytes were found to have the highest concentration ratio, primarily, the authors suggest, due to adsorption of sediment particulates to surfaces. All other trophic levels were found to have very low concentration ratios. In nearly all cases, concentrations of transuranics in vertebrate tissues were very low. Because of low food-chain transfer factors for most uranics, low concentrations in water, sediments, macrophytes, and invertebrates generally result in low concentrations of transuranics in vertebrate tissues (Bair and Thompson 1974, Eyman and Trabalka 1980).

Only 5 to 10 percent of the plutonium and americium in sediments in a process waste pond on the Hanford Reservation were found to be available for foodweb transfer (Emery et al. 1975). The remaining fraction appeared to be tightly bound to particles and would be transported ecologically in particulate form. Watercress had a plutonium concentration about equal to that found in the sediments, while dragonfly larvae and snails had americium levels approximating levels in the sediments. All remaining biota had plutonium and americium concentrations which were generally well below those of the sediments. Goldfish in the pond concentrated small amounts of both isotopes.

With respect to the distribution of several long-lived radionuclides within aquatic ecosystems, the work of Whicker et al. (1990) tends to confirm and strengthen the concept that many radionuclides tend to reside entirely in the sediments. It appears that this is true for cesium-137 and the transuranium elements. The rule also seems to hold for different types of systems with widely varying limnological

properties. As a consequence, only a very small fraction of the total system inventory can reside in the biotic components. For radionuclides that tend to sorb strongly to sediments, this distribution can probably be extended to most freshwater ecosystems.

### **9.1.2.3 Organic Compounds**

Each of the organic compounds found at OU5 (Table 9-1) are on the RCRA Appendix VIII and IX Lists, the Superfund Target Compound List, and the EPA Clean Water Act Priority Pollutants Compounds List and each is known to cause adverse acute and chronic effects on aquatic life, depending on their concentrations. Only two of the organic compounds listed in Table 9-1, phenol and di-n-butyl phthalate, are reported in Table 2-5 and Table 2-6 as being detected in surface water at OU5. Values for both of these compounds are less than the potential chemical-specific ARARs reported in Tables 3-1, 3-2, and 3-3. While these contaminants do not appear to be of concern based on these limited data, forthcoming data will be evaluated with respect to this determination. Chemicals which are readily accumulated by aquatic biota and are persistent in aqueous media (e.g., petroleum distillates) will require evaluation of their potential adverse affects on site-specific biota. While there is no history of their disposal, detection of pesticides, PCBs, or dioxins in the Phase I analytical program for abiotic media would also warrant further consideration in this environmental evaluation. Locations of elevated levels of such organic chemicals in groundwater will warrant evaluation due to the potential interaction with surface water and subsequent potential for exposure to receptor organisms.

### **9.1.3 Protected Wildlife, Vegetation, and Habitats**

#### **9.1.3.1 Wildlife**

The U.S. Fish & Wildlife Service has identified several listed endangered or threatened wildlife species which could possibly occur in the Rocky Flats Plant area. However, none is expected to occur because of lack of habitat. These species include the endangered bald eagle (Haliaeetus leucocephalus), the two threatened subspecies of peregrine falcon (Falco peregrinus tundris and F. p. anatum), the endangered whooping crane (Grus americana), and the endangered black-footed ferret (Mustela nigripes).

The bald eagle is primarily a winter resident around rivers and lakes, and the closest known nesting pairs are found at Barr Lake, 25 miles to the east of Rocky Flats. Although the Rocky Flats Plant Site lacks suitable bald eagle nesting habitat, bald eagles have been observed over the plant site, and one pair has been observed feeding regularly at Great Western Reservoir, located approximately 0.4 miles east of the site.

The whooping crane passes through Colorado during its spring and fall migrations. Whooping cranes blown off their migration course could use the Rocky Flats area as a night roost. These birds prefer large marshes and wetlands in broad open river bottoms and prairies. Such habitat is not present at Rocky Flats.

The two subspecies of peregrine falcon may occasionally occur in the Rocky Flats area as they hunt for prey. Nesting preferences are high cliff sides and river gorges, both of which are absent at Rocky Flats. However, nesting sites have been recorded to the west about 4 to 5 miles west of the site.

The historical geographic range of the black-footed ferret coincides with that of prairie dogs, a principal prey species. Although black-footed ferret populations are now extinct in the wild, large prairie dog towns sufficient to support a black-footed ferret population (>80 acres for black-tailed prairie dogs), if found at Rocky Flats, would be surveyed by approved methods (U.S. Fish and Wildlife Service 1986).

Several additional species are of special interest to the State of Colorado because they are endangered in the state, are game species, have small and/or declining populations, or are pest/nuisance species (Colorado Division of Wildlife 1981, 1982a, 1982b and 1985). These species will be identified and investigated during Task 2 and will be considered in the development of on-site food webs.

#### **9.1.3.2 Vegetation**

Ten federally-listed or -proposed plant species occur in Colorado, all of which are western slope species. None of these is known or expected to occur on or near Rocky Flats. A number of candidate species for federal listing are known to occur in Jefferson and Boulder Counties, but have not been identified at Rocky Flats.

#### **9.1.3.3 Wetlands**

Numerous regulations and acts have been promulgated to protect water-related resources, including wetlands. Wetlands play an important role in ecosystem processing and in providing habitat to a variety of plant and animal species. An assessment of Rocky Flats wetlands was completed in 1989 (EG&G 1990g); these wetlands currently fall under the jurisdiction of the U.S. Army Corps of Engineers. Wetlands occur along Woman Creek, portions of the South Interceptor Ditch, and at Ponds C-1 and C-2. DOE activities with a potential to impact wetlands will follow regulations designed for their protection.

## 9.2 ENVIRONMENTAL EVALUATION TASKS

An environmental evaluation at OU5 is necessary for Rocky Flats Plant to meet the requirements of Sections 121(b)(1) and (d) of CERCLA and Section 300.430(d) of the National Oil and Hazardous Substances Pollution Contingency Plan (55 FR 8666, 3/8/90). An environmental evaluation, in conjunction with the human health risk assessment, is required to ensure that remedial actions are protective of human health and the environment. Guidelines for conducting this evaluation, which is also called an ecological assessment, are provided by EPA in Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (U.S. EPA 1989c). Additional guidance is derived from EPA's Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document (U.S. EPA 1989d) and other guidance documents (Table 9-3).

The environmental evaluation is both a qualitative and quantitative appraisal of the actual or potential injury to biota other than humans and domesticated species due to contamination at OU5. The environmental evaluation is intended to reduce the inevitable uncertainty associated with understanding the environmental effects of contaminants present in OU5 and to give more definitive boundaries to that uncertainty during remediation.

The following plan for OU5 provides a framework for the review of existing data, the conduct of subsequent field investigations, and the preparation of the contamination assessment. Methodologies for the ecological and ecotoxicological field investigations (Tasks 3 and 9) are described in the Field Sampling Plan presented in Subsection 9.3.

Several of the tasks presented in the following plan will require coordination between the various operable units. In order to assure an integrated effort and to provide a means for obtaining input from regulatory agencies throughout the preliminary planning and implementation tasks, a Technical Working Group will be formed. As participants in this group, representatives from EG&G, DOE, and each of the regulatory review agencies will be involved in activities such as the determination of selection criteria for contaminants of concern, key receptor species and reference areas, and decisions regarding the use of existing data.

### 9.2.1 Task 1: Preliminary Planning

This task includes a definition of the study area, a determination of the scope of the environmental evaluation, identification of DQOs, and development of a plan for obtaining consensus on selection criteria for contaminants of concern, key receptor species, reference areas, and the field sampling approach/design. The scope of the environmental evaluation will describe the kind and amount of information that will be collected in the study. The biological parameters that are to be measured, estimated, and calculated will be described. The time period and boundaries of the evaluation will be

TABLE 9-3

**EXAMPLES OF EPA AND DOE GUIDANCE DOCUMENTS AND  
REFERENCES FOR CONDUCTING ENVIRONMENTAL EVALUATIONS**

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- Barnthouse, L.W., G.W. Suter, S.M. Bartell, J.J. Beauchamp, R.H. Gardener, E. Linder, R.V. O'Neill and A.E. Rosen. 1986. User's Manual for Ecological Risk Assessment. Environmental Sciences Division. Publication No. 2679, ORNL-6251.
- U.S. DOE. 1988a. Comprehensive Environmental Response, Compensation, and Liability Act Requirements. DOE Order 5400.YY. Draft, September 1988.
- U.S. DOE. 1988b. Radiation Effluent Monitoring and Environmental Surveillance. DOE Order 5400.XY, Draft, September 1988.
- U.S. DOE. 1990c. Radiation Protection of the Public and the Environment. DOE Order 5400.5
- U.S. EPA. 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. Office of Emergency and Remedial Response, Washington D.C., EPA/540/g-89/004.
- U.S. EPA. 1988c. Superfund Exposure Assessment Manual. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/1-88/001.
- U.S. EPA. 1988d. Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/2-88/003.
- U.S. EPA. 1989c. Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual. Interim Final. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/1-89/001.
- U.S. EPA. 1989d. Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document. Office of Research and Development. EPA/600/3-89/013.
- U.S. EPA. 1989e. Exposure Factors Handbook. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-89/043.
- U.S. EPA. 1990. Guidance for Data Useability in Risk Assessment. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/G-90/008.9.2.1 Task 1: Preliminary Planning

designated. Depending on the available pathways for exposure and the habitats potentially exposed to contamination, the study area for this ecological assessment may extend beyond the boundaries of each IHSS and Woman Creek.

#### **9.2.1.1 Selection Criteria for Contaminants of Concern**

Because not all contaminants found at OU5 will have adverse effects on biota, the list of chemicals to be evaluated can be narrowed. Chemical and species-specific criteria (e.g., likelihood of exposure) will be used for selecting those contaminants that are of particular concern from an ecological perspective at OU5. Chemical, physical and toxicological criteria will be used in selecting contaminants of concern. Selection of these specific criteria will be developed in consultation with EPA and the State. Examples of the potential criteria to be evaluated in selecting contaminants of concern are shown in Table 9-4.

Although the selection process for contaminants of concern parallels that for the Human Health Risk Assessment, the lists may differ somewhat based on contaminant fate and transport characteristics and species-specific toxicities. The process for selecting contaminants of concern is currently being developed as a Standard Operating Procedure (SOP). Selection of the contaminants of concern will be evaluated in accordance with EPA guidance (U.S. EPA 1989c). An appropriate scoring system will be used to quantify the selection as much as possible. The selection process for these criteria will take into account the limited data that are available to quantify some of these factors (e.g., concentrations detected on site; frequency of detection). In these cases, a weighting factor will be used to assign such criteria a low reliance. The screening values for each the criteria will be used as tools to help select chemicals that need further assessment. They will not be used as limits which indicate absolute "no adverse effects" levels. Actual site-specific conditions will determine the potential for adverse effects in receptor species at OU5.

#### **9.2.1.2 Identification of Key Receptors**

Key receptors are those species or taxon which are or may be sensitive to the particular contaminants of concern. Organisms at each trophic level within a food web differ in their sensitivity and the ways they take in, accumulate, metabolize, distribute, and expel contaminants. The susceptibility of a particular organism also varies with the mechanism through which contaminants are taken up from the environment. In general, the following criteria determine the susceptibility of the receptor to a particular contaminant (U.S. EPA 1989c):

- The rapidity with which the contaminant is absorbed from the environment
- Sensitivity of the receptor's tissues to the dosage incurred

**TABLE 9-4**

**POTENTIAL SELECTION CRITERIA FOR CONTAMINANTS OF CONCERN**

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Concentrations detected on site

Frequency of detection

Historical disposal information

- Type
- Quantity

Mobility in environmental media

Chemical fate (transport)

- Adsorption coefficient
- Partition coefficient (water-octanol)
- Water solubility
- Vapor pressure

Persistence

- Biodegradation
- Chemical degradation

Bioaccumulation potential

Bioavailability

Biotransformation potential

Background concentrations

Biochemistry

- Essential nutrient
- Enzyme inhibitor

Toxicity

Treatability

---

- Relationship between tissue sensitivity and the expression of symptoms of toxic injury
- The rapidity of repair or accommodation to the toxic injury

Selection of key receptors will depend on the ability to detect toxic injury in the organism or subsequent adverse effects to the population. National standards on the definitions of injury to biological receptors are found in the Natural Resource Damage Assessment Rule [40 CFR Subtitle A Section 11.62 (f)]. These include death, disease, behavioral abnormalities, cancer, physiological malfunctions, and physical deformation. Additional methods for detecting injury to biological resources are provided in the Type B Technical Information Document: Injury to Fish and Wildlife Species (U.S. DOI 1987). The procedures described in these documents provide a framework for determining what categories of effects might be observed in the field during the site visit and subsequent surveys and for selecting appropriate study methods to establish relationships between contaminant distribution and concentration in the physical environment and biological consequences in the receptor organisms and populations (Reagan and Fordham 1991). By using this approach to focus efforts on examining specific effects in key receptor species, costs and sampling efforts will be reduced.

The selection of key receptors is in part a subjective decision based on species dominance or judged importance in the food chain. Selection criteria for key receptors will include consideration of the following:

- Sensitivity to contaminants
- Listing as rare, threatened, or endangered by a governmental organization
- Game species
- A key component of ecosystem structure and function (e.g., abundant prey for other important species)

Additional criteria used in the selection of key receptors include habitat preferences, food preferences, and other behavioral characteristics which can determine population size and distribution in an area or significantly affect the potential for exposure. Key receptors may include game species such as mule deer (Odocoileus hemionus) which is mobile and has a large home range; or an organism that is sedentary or has a more restricted movement, such as plants, some invertebrates, and some small vertebrates. For contaminants that bioaccumulate, the effects are usually most severe for organisms at the top of the food chain (e.g., top predators). Examination of contaminant effects on these more mobile species may necessitate the integration of data from different OUs.

A checklist of OU5 biota will be developed in conjunction with the ecological field inventory. The initial list of key receptors will be chosen from the checklist based on the selection criteria and will include organisms from each trophic level. The documented selection analysis will include an evaluation of the receptor's relation to potential contaminant exposure through both direct contaminant accumulation from the abiotic environment and bioaccumulation through the food chain. Examples of key receptors species (or taxon) likely to be on this list are presented in Table 9-5. This list will be refined as information is evaluated on known contaminant effects on these species (or similar species) and the documented levels of contamination present at the site.

Key receptors will be selected from this list for subsequent detailed food web analyses, and possible tissue sampling or other ecotoxicological analyses. Selection of key receptors for tissue analyses will depend on the receptor's suitability for sampling, sample size requirements, results of the preliminary exposure assessment, and expectation for finding contaminants in the tissues sampled (see Subsections 9.2.9 and 9.2.10). Final selection of the contaminants of concern and key receptors will provide the basis for the contamination assessment (Tasks 4 through 7). In the contamination assessment, food webs and contaminant exposure pathways will be developed for OU5. Information on these food webs will be used to relate quantitative data on contaminants in the abiotic environment to adverse effects in biota and to evaluate potential impacts to biota due to contaminant exposure.

#### **9.2.1.3 Reference Areas**

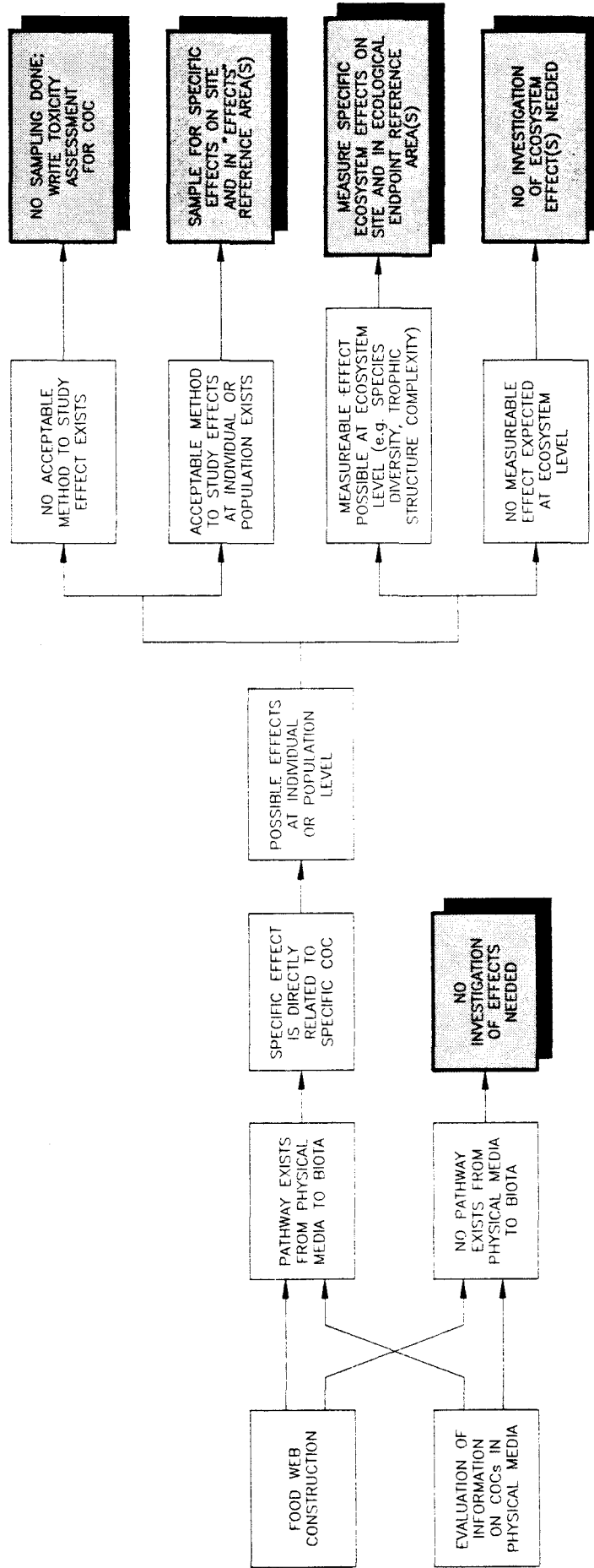
Determination of criteria for selection and sampling of reference areas will be coordinated between operable units and will be addressed in the SOPs. Reference areas will be identified as needed for terrestrial, wetland, and aquatic species and will be selected based on measurement endpoints. Referenced areas are likely to be selected in the northwestern portion of Rocky Flats Plant away from potential effects associated with release from either Rocky Flats or OU5. Additional off-site areas may also be selected, as appropriate.

Reference areas need not be selected where current and historical data are available to assess impacts from OU5 contaminants. Where such data are not available, one or more reference areas may be selected based upon their similarity to OU5, their lack of exposure to contamination from Rocky Flats or other sources, and the selected measurement endpoint. If more than one habitat or ecosystem type (e.g., terrestrial and aquatic) is to be assessed at OU5, comparable reference areas may be established for each, or a reference area may be selected containing those habitats or ecosystem types in a comparable distribution. For OU5, at least one reference area may be located upstream of the assessment area unless conditions indicate the area is unsuitable as a reference area. Data collected at the reference area will be compared where possible to values reported in the scientific literature to demonstrate that the data represent a normal range of conditions. Methods used to collect data at the reference area will be comparable to those used at OU5.

TABLE 9-5

**POTENTIAL KEY BIOLOGICAL RECEPTORS  
FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT OU5**

| Community                  | Taxon                                                                                                                               |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Periphyton                 | Green algae<br>Blue-green algae                                                                                                     |
| Benthic Macroinvertebrates | Mayflies (larvae)<br>Caddis flies (larvae)<br>Chironomids (larvae)<br>Crayfish                                                      |
| Fish                       | Fathead minnow<br>Bluegill                                                                                                          |
| Reptiles                   | Garter snake<br>Bull snake                                                                                                          |
| Mammals                    | Deer mouse<br>Northern pocket gopher<br>Microtines<br>Rabbit<br>Coyote                                                              |
| Birds                      | Mourning dove<br>Mallard<br>Killdeer<br>Red-winged blackbird<br>Ring-necked pheasant<br>Cormorant<br>Blue heron<br>Great-horned owl |
| Terrestrial Invertebrates  | Earthworms<br>Grasshoppers                                                                                                          |
| Grasses                    | Western wheatgrass<br>Blue grama<br>Cheatgrass                                                                                      |
| Shrubs/Forbs               | Snowberry<br>Willows<br>Bindweed<br>Sunflower<br>Cattails<br>Pondweed                                                               |
| Microbial Populations      | Entire population                                                                                                                   |



U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 5

PHASE I RFI/RI WORK PLAN

DECISION PROCESS FOR THE  
INVESTIGATION OF INDIVIDUAL,  
POPULATION, AND ECOSYSTEM LEVEL  
EFFECTS AND FOR THE USE OF  
REFERENCE AREAS FOR COC EFFECTS

FIGURE 9-2

MAY 1991

The decision process for using reference areas in the investigation of adverse effects from contamination at Rocky Flats is presented in Figure 9-2. As shown in this figure, a number of activities will take place prior to the selection of reference areas. These activities include the determination that:

- A pathway (inhalation, ingestion, etc.) exists for the movement of a contaminant of concern from the physical abiota media to biota
- Acceptable methods are available to study the resultant effects of contamination at the individual, population, or ecosystem level (e.g., species diversity, trophic structure complexity)

Selection of a reference area(s) will ultimately depend on the specific effect or ecological endpoint that is to be measured. More than one reference area may be used depending on the effects to be studied. The selection of reference areas would be made to meet DQOs (U.S. EPA 1989c) and the selected assessment and measurement endpoints. Two basic criteria would be employed in the selection and establishment of reference areas:

1. The reference areas will be similar to OU5 in terms of soil series, topography, aspect, vegetation, habitat types and plant and animal assemblages.
2. The reference areas, including vegetation and wildlife, have not been impacted by releases from OU5 or other Rocky Flats Plant operable units.

#### **9.2.1.4 Data Quality Objectives**

The DQO development process will follow the three steps recommended by EPA (1989d). Step I of the DQO process involves preparing definitions and concise DQOs. Examples of Step I program DQOs for this environmental evaluation include the following:

- Identify appropriate site-specific receptor species, contaminants of concern, and exposure pathways to determine if there is a potential for adverse effects to occur as a result of contamination. This step includes determination of relevant contaminant concentrations in biological tissues.
- Evaluate the potential for impacts to occur to biological resources outside the boundaries of OU5 or the Rocky Flats Plant.
- Evaluate the need for remediation to protect the environment.

Steps II and III of the DQO process include identification of data uses and needs and design of the data collection program. Products of Step II include proposed statements of the type and quality of environmental data required to support the DQOs, along with other technical constraints on the data collection program. The objective of Step III is to develop data collection plans that will meet the criteria and constraints established in Steps I and II. Step III results in the specification of methods by which data of acceptable quality and quantity will be obtained. The DQO development process will continue as scoping of the environmental evaluation becomes more refined. Additional Step I decision-type DQOs may be needed or data collection-type DQOs may be modified based on Task 1 and Task 2 results and subsequent refinement of the field sampling plan.

#### **9.2.1.5 Field Sampling Approach/Design**

The Field Sampling Plan presented in Subsection 9.3 is designed to be flexible so that it can be revised as additional data are collected. Flexibility in the Field Sampling Plan will ensure that field data collection activities will be comparable to and compatible with previous data collection activities performed at the site while providing a mechanism for planning and approving new field activities. The Field Sampling Plan, in conjunction with the SOPs for Ecology (Volume V- in preparation by EG&G) will provide guidance for all field work by defining the sampling and data-gathering methods to be used on the project.

#### **9.2.2 Task 2: Data Collection/Evaluation and Conceptual Model Development**

As an integral part of the RFI/RI process, Task 2 of the environmental evaluation will focus on accumulating and analyzing pertinent information on three major areas:

- Species, populations, habitats, and food web interrelationships
- Types, distribution and concentrations of contaminants in the abiotic environment (e.g., soil, surface water, groundwater, and air)
- Preliminary determination of potential exposure pathways and potential contaminant effects on OU5 biota based on literature review

The principal subtasks in Task 2 include Literature Review and Site Characterization. These subtasks will be performed in conjunction with Task 3, Ecological Field Investigation. Information that will be developed from these tasks includes the following:

- Chemical inventory/Contaminants of Concern - Existing information including that obtained on chemical contaminants from other investigations at Rocky Flats and other

DOE facilities will be used in the development of a preliminary list of contaminants of concern.

- Initial toxicity test data - Preliminary data on the toxicity of potentially complex chemical mixtures in OU5 surface waters.
- Descriptive field surveys - Inventory of OU5 biota and locations of obvious zones of chemical contamination, ecological effects, and human disturbance.
- Species inventory - Plant and animal species known to occur within OU5 or to potentially contact contaminants at OU5 and their trophic relationships.
- Population characteristics - Information on the abundance of key species (see SOPs).
- Food habit studies - Available information from literature sources to supplement field observations and possible gut content analysis on key receptor species.

#### **9.2.2.1 Literature Review**

As an essential part of Task 2, a review of available documents, aerial photographs, and data relevant to the site will be completed. This will allow compilation of a database from which to determine data gaps and to provide evidence for a defensible field sampling program. Prior studies by DOE and the Rocky Flats Plant operating contractors will be reviewed and evaluated. Information to be reviewed will include the following:

- Project files maintained by Rockwell International and EG&G
- Project reports and documents on file at the Front Range Community College Library, at the Colorado Department of Health, and at the Colorado Division of Wildlife
- DOE documents and DOE orders
- The Phase I database
- The Rocky Flats EIS database
- Data from ongoing environmental monitoring and National Pollution Discharge Elimination System (NPDES) programs

- Studies conducted at Rocky Flats on radionuclide uptake, retention, and effects on plant and animal populations
- Scientific literature, including ecological and risk assessment reports, from other DOE facilities (Oak Ridge National Laboratory, Los Alamos, Hanford, Savannah River, Fernald)

If available and applicable, historical data will be used. Where the same methods are not used in the collection of new data, use of historical data will depend on the demonstrated comparability of the data collection methods. Where possible, analytical data files will be made available in an electronic file format.

#### **9.2.2.2 Site Characterization**

Environmental resources at the site will be characterized based on reviews of existing literature and reports, including results from the Phase I RFI/RI investigation, other operable unit RFI/RI investigations and the Task 3 ecological field investigation. The description of the site will be presented in terms of the following distinct resource areas:

- Meteorology/air quality
- Soils
- Sediments
- Geology
- Surface and groundwater hydrology
- Terrestrial ecology
- Aquatic ecology
- Protected/important species and habitats

The purpose of the site characterization is to describe resource conditions as they exist without remediation. The narrative with supporting data will include descriptions of each resource, with attendant tables and figures, as appropriate, to depict, in a concise and clear fashion, site conditions, particularly as they influence contaminant fate and transport.

Included in this task is the development of a community food web model (Reagan and Fordham 1991) to describe the feeding relationships of organisms at Rocky Flats Plant. Food web construction begins with gathering information to evaluate the food habits of species or species groups (e.g., grasshoppers) found or potentially occurring on site. Standard computer searches will be augmented with searches of local university libraries to locate any regionally pertinent studies on food habits. The preliminary list of important species, compiled from background information, will be completed based on observations

of presence and abundance made during the ecological site surveys and on trophic level data obtained from the food web model. Based on the model, a modified list of species will be made using toxicological information (toxicity assessment) to determine which species or species groups might be most affected or most sensitive to the chemical(s) of interest.

Data from past studies and preliminary data from current environmental studies will be used to better define the present distribution of contaminants in the abiotic environment and to develop an initial food web model. The food web model in conjunction with a preliminary pathways analysis will identify likely or presumed exposure pathways or combinations of pathways and receptor species at risk. Based on this preliminary information, the Task 3 and Task 9 field investigation sampling approach/designs may be revised.

### **9.2.3 Task 3: Ecological Field Investigation**

The Phase I field investigation for OU5 consists of the following separate programs: (1) the air quality program which will entail emissions estimation and modeling; (2) the soils, surface water, and groundwater sampling programs, which will be conducted as part of the Phase I RFI/RI activities; and (3) the terrestrial and aquatic biota sampling program, which will be conducted as part of this environmental evaluation.

#### **9.2.3.1 Air Quality**

A site-wide air quality monitoring program is being conducted at Rocky Flats (see Section 2.3.6). Specific air monitoring is also being done at OU5. These data can be used to model airborne deposition and transport of contaminants through the food web to potential receptors. Such modeling could be performed where data in abiotic media are inadequate. Where the inhalation pathway is considered to be significant in the case of OU5 biota, a detailed pathways analysis and assessment of potential adverse effects using these transport model data will be performed.

#### **9.2.3.2 Soils**

Few data exist on contaminants present in surficial materials at OU5. Groundwater monitoring wells have been installed at several locations within the drainages, but all wells are outside OU5 IHSS boundaries. Soil samples from various depths in these wells were analyzed. These data have not been validated, and there is some uncertainty in the unvalidated data.

The purpose of the Phase I RFI/RI sampling and analysis program is to provide data for characterizing the IHSSs and for confirming the presence or absence of contamination. The Phase I RFI/RI Work Plan proposes to collect soil samples from each of the IHSSs at OU5. Surficial soil samples will be collected

in the Ash Pits, the Original Landfill, and the Surface Disturbances areas. Surface soils samples will be analyzed for radionuclides and metals in the Ash Pits and proximal to the Original Landfill, and additionally for organics in the Surface Disturbance Areas. Soil samples will be collected from IHSS 115, Original Landfill, only where there are radiation hotspots or high soil gas readings. The list of soil analysis parameters is presented in Table 7-5, and the planned analytical program is presented in Table 7-6. In addition to these analyses, soil analyses will be conducted in the field and laboratory to confirm and clarify Soil Conservation Service descriptions and classifications. This information will be used to evaluate suitability of the soils for plant growth and to assist in the selection of suitable reference areas.

Surficial soil samples will be of prime importance for determining source contaminants for biota. This uppermost layer provides the major source of nutrients and contaminant uptake for the vegetation under study and is also a source of potential contaminant ingestion to wildlife. Soil samples from all depths are related to surface water and groundwater regimes. Fluids moving through the soils can leach contaminants, transport them through available flow paths, and deposit them in downgradient environments. Contamination in soil and groundwater at a depth of greater than 20 feet (maximum depth of burrowing animals and plant root penetration) will not be considered to affect biota.

The sampling and analysis programs under the Phase I RFI/RI field investigations have been reviewed and modified as necessary to ensure that sampling intervals, methods, and analytical program are appropriate and meet the DQOs of the environmental evaluation. Data from the Phase III OU1 RFI/RI program and the Phase II OU2 RFI/RI Program will also be evaluated for use in characterizing the nature and areal extent of surface soil contamination in the vicinity of OU5. The information will be used to help identify exposure pathways for the environmental assessment.

#### **9.2.3.3 Surface Water and Sediments**

Surface water and sediment samples are collected on a regular basis as part of ongoing investigations at OU5 as well as nearby OUs 1 and 2. These investigations will continue. This Phase I RFI/RI Work Plan proposes extensive sampling along Woman Creek, the South Interceptor Ditch, and in Ponds C-1 and C-2. In addition, samples will be collected upstream of the Rocky Flats Plant to provide background data. Samples will be analyzed for metals, radionuclides, inorganics, and organics. Total organic carbon in soils and sediments and sediment grain size will also be determined as part of the analytical program.

Surface water sampling and analytical results presented in the Final OU1 RFI/RI Work Plan and the Draft Final OU2 RFI/RI Work Plan will be evaluated with respect to the abiotic sampling programs planned in the nearby operable units to assure the abiotic data needs for the environmental evaluations at each of these OUs are addressed. Sampling locations and programs presented in each of these work plans

will be integrated as part of the field sampling implementation program with OU1 and OU2 sampling locations. Chemical results from the OU1 and OU2 surface sampling locations will be reviewed and incorporated into the OU5 environmental evaluation as needed.

#### **9.2.3.4 Groundwater**

Groundwater monitoring wells upgradient and downgradient of some of the IHSSs provide limited information on groundwater conditions in Woman Creek Drainage. This Phase I RFI/RI proposes to install monitoring wells downgradient of the Original Landfill, Ash Pits, and Ponds C-1 and C-2. The laboratory analytical results will be used to assess the presence or absence of groundwater contamination and to assess the exposure pathway, if present.

Data from the Phase III OU1 RFI/RI Program and the Phase II OU2 RFI/RI Program will also aid in characterizing the nature and areal extent of groundwater contamination in the vicinity of the site. The hydrogeologic information and laboratory analytical results from these planned boring and well installation programs will likewise be incorporated in this environmental evaluation where applicable. The information will be used to assist in determining the nature and extent of contamination in shallow groundwater and help identify exposure pathways for the environmental assessment.

#### **9.2.3.5 Terrestrial and Aquatic Biota**

Terrestrial and aquatic species in the Rocky Flats Plant area have been described by several researchers (Weber et al. 1974; Clark 1977; Clark et al. 1980; Quick 1964; Winsor 1975; CDOW 1981; CDOW 1982a, 1982b); most of these reports are summarized in the Final EIS (U.S. DOE 1980). In addition, terrestrial and aquatic radioecology studies conducted by Colorado State University (CSU) and DOE (Rockwell International 1986; Paine 1980; Johnson et al. 1974; Little 1976; Hiatt 1977), along with annual monitoring programs at Rocky Flats Plant, have provided information on the plants and animals in the area and their relative distribution.

Limited field surveys will be conducted in Task 3 to characterize current biological site conditions in terms of species presence, habitat characteristics and/or community organization. The emphasis will be to describe the structure of the biological communities at OU5 in order to identify potential contaminant pathways, biotic receptors, and key species.

Initial aquatic toxicity tests using Ceriodaphnia spp. and fathead minnows will be conducted at OU5 under Task 3. The technical objective of the toxicity tests is to provide a screening mechanism to aid in the determination of the nature and extent of contamination, particularly since there is the potential for exposure to mixtures of contaminants. EPA recognizes the usefulness of such toxicity testing as a means for integrating the effects of all toxic pollutants, which cannot be measured by chemical analysis.

Standardized EPA acute and chronic test methods will be followed in accordance with NPDES toxicity testing procedures currently being used at Rocky Flats.

### Vegetation

The objectives of the vegetation sampling program are to provide data for: (1) the description of site vegetation characteristics; (2) identification of potential exposure pathways from contaminant releases to higher trophic-level receptors; (3) selection of key species for contaminant analysis to determine background conditions for OU5; and (4) identification of any protected vegetation species or habitats.

A number of habitat types are expected to be found in the Woman Creek Drainage (Clark et al. 1980). Grasses characteristic of the short grass plains are expected to be abundant. Representative species include blue grama (Bouteloua gracilis), Junegrass (Koeleria cristata), dropseed (Sporobolus spp.), slender wheatgrass (Agropyron trachycaulum), and green needlegrass (Stipa viridula), which are interspersed with other grasses, shrubs, and a variety of annual flowering plants. Transects will be established at each of the IHSSs, along the South Interceptor Ditch, and along Woman Creek Drainage to collect phytosociological data on biomass and cover, shrub/tree density and frequency, and species presence.

### Wetland Vegetation

Wetlands have been identified along Woman Creek and the South Interceptor Ditch (EG&G 1990g). These occur as linear wetlands that support hydrophytic vegetation species including sandbar willow (Salix exigua), american watercress (Barbarea orthoceras), and plains cottonwood (Populus sargentii). Other species associated with these wetlands include broad-leaf cattail (Typha latifolia), baltic rush (Juncus articus), cordgrass (Spartina pectinata), silver sedge (Carex praegracilis), and various bulrushes (Scirpus spp.). Transects will be established in adjacent wetland vegetation habitats at the designated aquatic sampling locations along the South Interceptor Ditch and Woman Creek and around Ponds C-1 and C-2 to collect phytosociological data on biomass and cover, shrub/tree density and frequency, and species presence.

### Periphyton

The periphyton community is a closely-adhering group of organisms that form mat-like communities on rocks, other solid objects, or the stream bottom. The community is composed of algae, bacteria, fungi, detritus, and other macroscopic heterotrophic organisms. Because of the large surface-to-volume ratio of its constituents, periphyton have been found to be an excellent indicator community for accumulation of contaminants. Periphyton samples will be collected at designated locations (see Section 9.3.2.2) on the South Interceptor Ditch, along Woman Creek, and at Ponds C-1 and C-2.

Periphyton communities provide a sensitive mechanism to detect changes in aquatic environments that result from the introduction of contaminants. Taxonomic composition and relative abundance of periphyton can be measured on natural substrates as well as standardized artificial substrates. On hard artificial substrates, data on algal abundance, biomass, and species composition will be obtained by removing the substrate and by scraping or brushing the flora from a measured area into a container.

#### Benthic Macroinvertebrates

Benthic macroinvertebrates may exist in rocky/gravelly substrates or as soft bottom communities along portions of Woman Creek, the South Interceptor Ditch, and Ponds C-1 and C-2. The soft-bottom benthos are those macroscopic invertebrates inhabiting mud or silt substrates, whereas the immature stages of insects inhabit rock surfaces, rooted stems, and leaves or gravelly substrates. Because these communities are essentially stationary, they are good indicators of past and present habitat contamination. Additionally, their feeding methods (filtering microscopic organisms and fine materials, preying on smaller invertebrates, and grazing on periphyton), suggest that benthic species are ingesting other organisms that are potentially concentrating contaminants. Designated locations in the South Interceptor Ditch, Woman Creek, and Ponds C-1 and C-2 (see Section 9.3.2.2) will be sampled for benthic organisms.

#### Fish

Fish can be important components of ecological assessments because they are relatively long-lived, occupy upper trophic levels of aquatic ecosystems, and they may spend their entire lives in relatively small areas. Fish species representing both herbivores and carnivores are likely present in OU5 aquatic habitats and may demonstrate biomagnification of contaminants within the pond or creek ecosystem. Designated aquatic sampling locations (see Section 9.3.2.2) will be sampled for fish where the habitat is appropriate.

#### Terrestrial Wildlife

A field survey will be conducted to gather data on animal communities at Woman Creek Drainage. The objective of the animal life survey is to: (1) describe the existing animal community at Woman Creek Drainage; (2) identify potential contaminant pathways through trophic levels; (3) develop food web models including contribution from vegetation; (4) identify key species for potential collection and tissue analysis; and (5) identify any protected species.

The field survey as presented in the Field Sampling Plan (see Section 9.3) will document the presence of terrestrial species and allow for a general description of the community. Some species (e.g.,

songbirds, larger mammals, reptiles, and raptors) may use the area daily, seasonally or sporadically, or wander through as vagrants. Survey timing and techniques will consider these uses.

#### **9.2.4 Contamination Assessment (Tasks 4 through 7)**

The contamination assessment includes Tasks 4 through 7. The two major objectives of the contamination assessment are to:

- Obtain quantitative information on the types, concentrations, and distribution of contaminants in selected species, and
- Evaluate the effects of contamination in the abiotic environment on ecological systems.

Conducting a contamination assessment requires an evaluation of chemical and radiological exposures and the subsequent toxicological effects on key species. Of specific importance in the contamination assessment is the identification of exposure points, the measurement of contaminant concentrations at those points, and the determination of potential impacts or injury. Impacts may result from movement of contaminants through ecological systems or from direct exposure (inhalation, ingestion, or deposition).

The Contamination Assessment for OU5 will be based on existing environmental criteria, published toxicological literature, and existing, site-specific environmental evaluations. The program design will be integrated with other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be related to contaminant levels and effects in biota. A preliminary contamination assessment will be made in Task 2 based on the site characterization and contaminant identification activities. The preliminary Task 2 assessment will be used to revise the Task 9 ecotoxicological field investigation sampling design. The contamination assessment process described in the following tasks will include the development of a site-specific pathways model to quantify the potential for contaminant exposure and adverse effects in biota.

The objectives and description of work for each of the contamination assessment tasks is described below.

#### **9.2.5 Task 4: Toxicity Assessment**

This assessment will include a summary of the types of adverse effects on biota associated with exposure to site-related chemicals, relationships between magnitude of exposures and adverse effects, and related uncertainties for contaminant toxicity, particularly with respect to wildlife. Ecological

receptor health effects will be characterized using EPA-derived critical toxicity values when available in addition to selected literature pertaining to site- and receptor-specific parameters.

The toxicity assessment will provide brief toxicological profiles centered on health effects information on wildlife populations. The profiles will cover the major health effects information available for each contaminant of concern. Data pertaining to wildlife species will be emphasized, and information on domestic or laboratory animals will be used when wildlife data are unavailable. Adequacy of the existing database will be evaluated as part of this task.

#### **9.2.6 Task 5: Exposure Assessment and Pathways Model**

This task will identify the exposure or migration pathways of the contaminants, taking into account environmental fate and transport through both physical and biological means. Each pathway will be described in terms of the chemical(s) and media involved and the potential ecological receptors. The exposure assessment process will include the following three subtasks:

- Identify exposure pathways
- Determine exposure points and concentrations
- Estimate chemical intake for receptors

Each of these subtasks is described below.

##### **9.2.6.1 Exposure Pathways**

The purpose of this subtask is to qualitatively identify the actual or potential pathways by which various biological receptors at or near OU5 might be exposed to site-related chemicals or radionuclides. The exposure pathway analysis will address the following four elements:

- A chemical/ radionuclide source and mechanism of release to the environment
- An environmental transport medium (e.g., soil, water, air) for the released chemical/ radionuclide
- A point of potential biological contact with the contaminated medium
- A biological uptake mechanism at the point of exposure

All four elements must be present for an exposure pathway to be complete and for exposure to occur. Exposure pathways will be evaluated and modeled, where possible, using the pathways approach (Reagan and Fordham 1991; Thomann 1981).

The pathways approach uses a bioaccumulation model of contaminant transfer through a food web. The model links contamination in soil and water to contamination in biota. The pathways model approach blends standard environmental assessment methods with ecological and toxicological modeling to produce an integrated procedure to selecting indicator species and conducting an investigation of ecosystem effects resulting from contamination in soil and water. Where possible, uncertainty in the model is reduced by direct sampling (i.e., tissue analysis).

Toxicity tests, such as those proposed for Task 3, can also be used to conduct a direct effects-related investigation. Additional toxicity tests may be designed based on the pathways model results.

#### **9.2.6.2 Determination of Exposure Points and Concentrations**

The identified exposure points are those locations where key ecological receptor species may contact the contaminants of concern. Potential for exposure depends on characteristics of the contaminant, the organism, and the environment. Determination of exposure points entails an analysis of key receptor species, locations, and food habits in relation to potential contaminant exposure both through direct contaminant accumulation or deposition from the abiotic environment and through indirect bioaccumulation. The exposure assessment for OU5 will provide information on the following:

- What organisms are actually or potentially exposed to contaminants from OU5
- What the significant routes of exposure are
- What amounts of each contaminant organisms are actually or potentially exposed to
- Duration of exposure
- Frequency of exposure
- Seasonal and climatic variations in conditions which are likely to affect exposure
- Site-specific geophysical, physical, and chemical conditions affecting exposure

A determination of the nature and extent of contamination in the abiotic media (air, soils, surface water, and groundwater) is presented in this Phase I RFI/RI Work Plan for Woman Creek Drainage. Phase I data, where available and validated, will be summarized and used to characterize source areas and release characteristics at the site. The exact exposure points can be expected to vary depending on both the contaminant and the key receptor species under consideration.

Concentrations of chemicals that are likely to have the greatest impact (based on concentration in the environment, toxicity values, and biological uptake) will be determined by actual environmental media

sampling for each exposure point or by environmental fate and transport modeling. Fate, transport, and endpoint contamination levels in abiotic media may be modeled, where necessary, using environmental multi-media risk assessment models. Such models can provide the potential maximum concentrations of chemicals at the exposure points by which to evaluate the "worst-case" scenario.

#### **9.2.6.3 Estimation of Chemical Intake by Key Receptor Species**

This step includes an evaluation of key receptor species' contaminant uptake by direct routes (i.e., inhalation, ingestion, dermal contact) and indirect routes (bioconcentration, bioaccumulation, biomagnification). The amounts of chemical and radiological uptake will be estimated using appropriate conservative assumptions, site-specific analytical data on contaminant concentrations in abiotic and biotic media, and forthcoming guidance from EPA's Wildlife Exposure Factors Handbook (to be published in 1991). The pathways analysis model (Reagan and Fordham 1991; Thomann 1981) will be used to establish relationships between concentrations of a chemical in different media with concentrations known to cause adverse effects.

Direct measurement of contaminant uptake through tissue analyses will be conducted during Task 9 of the environmental evaluation. Such site-specific data and field observations will be used to reduce uncertainty in the pathways model and strengthen interpretation of the overall study.

#### **9.2.7 Task 6: Contamination Characterization**

Contamination characterization entails the integration of abiotic exposure concentrations and reasonable worst-case assumptions with the information developed during the exposure and toxicity assessments to characterize current and potential adverse biological effects (e.g., death, diminished reproductive success, reduced population levels, etc.) posed by OU5 contamination. The potential impacts from all exposure routes (inhalation, ingestion, and dermal contact) and all media (air, soil, groundwater, and surface water/ sediment) will be included in this evaluation as appropriate according to EPA guidance (U.S. EPA 1989c).

Characterization of adverse effects on receptor species and their populations is generally more qualitative in nature than characterizing human risks. This is because the toxicological effects of most chemicals have not been well documented for most species. Criteria or toxicological benchmarks that are usable and applicable for the evaluation of ecological effects are generally limited. EPA AWQC and Maximum Allowable Tissue Concentrations (MATC) are the most readily available criteria. Criteria found in federal and Colorado state laws and regulations pertaining to the preservation and protection of natural resources can also be used. Criteria may also be derived from information developed for use under other environmental statutes, such as the Toxic Substances Control Act or the Federal Insecticide, Fungicide and Rodenticide Act. An attempt will be made to consider the adverse effects of chemicals

on populations and habitats rather than on individual members of a species according to EPA guidance (1989c, 1989d). Where specific information is available in the published literature, a more quantitative evaluation of effects will be made using the site-specific pathways model. This approach is in agreement with EPA guidance (U.S. EPA 1989c).

#### **9.2.8 Task 7: Uncertainty Analysis**

The process of assessing ecological effects is one of estimation under conditions of uncertainty. Understanding the effects of environmental stresses resulting from contamination on real populations depends on complex abiotic and biotic processes that cannot be reproduced in the laboratory. To address uncertainties, the OU5 environmental evaluation will present each conclusion, along with the issues that support and fail to support the conclusion, and the uncertainty accompanying the conclusion. Factors that limit or prevent development of definitive conclusions will also be discussed. In summarizing the assessment data, the following sources of uncertainty and limitations will be specified:

- Variance estimates for all statistics
- Assumptions and the range of conditions underlying use of statistics and models
- Narrative explanations of other sources of potential error

Validation and calibration of the pathways model will also be used where practicable.

#### **9.2.9 Task 8: Planning**

Task 8 will include planning for tissue analysis studies and any additional ecotoxicological studies (e.g., reproductive success, enzyme analyses, microbial respiration) needed to assess adverse effects from the contaminants of concern on key receptors. Initial designing for the Task 9 ecotoxicological field investigations will begin after contaminants of concern and key receptors have been selected in Task 2. Species to be sampled for tissue analyses will be designated to the earliest extent possible in order to avoid a duplication of the Task 3 sampling effort.

The need for measuring additional ecotoxicological endpoints in Task 9 will be evaluated based on the pathways analyses and published information on direct toxic effects. Selection of field methodologies will be based on a review of available scientific literature providing quantitative data for the species of concern or similar test species. Analysis of population, habitat, or ecosystem changes will be based on species or habitats that represent broad components of the ecosystem or are especially sensitive to the contaminants. In order to select methodologies for the ecotoxicological field sampling program, the biological response under consideration and the proposed methodology should satisfy program DQOs as well as the following more specific criteria:

- The biological response is a well-defined, easily identifiable, and documented response to the designated contaminant(s) of concern (i.e., methodology and measurement endpoint are appropriate to the exposure pathway).
- Exposure to the contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms.
- Methodology is capable of demonstrating a measurable biological response distinguishable from other environmental factors such as weather or physical site disturbance.
- The biological response can be measured using a published standardized laboratory or field testing methodology.
- The biological response measurement is practical to perform and produces scientifically valid results (e.g., sample size is large enough to have useful power and small Type I error).

Tissue studies to document site-specific contamination will be conducted in Task 9 for both aquatic and terrestrial systems. Tissue analyses will be conducted on selected species from OU5 and reference areas (if necessary) to document current levels of specific target analytes. Information from the Task 2 data evaluation and Task 3 field survey will determine the species and contaminants to be tested and the methods to be used. Selection of the target analytes, species, and tissues will depend on an initial determination as to which contaminants are likely to adversely impact biota and which contaminants are likely to be present in concentrations sufficient for detection.

Acute and chronic aquatic toxicity tests using fathead minnows and Ceriodaphnia spp. are proposed for Task 3 (see Subsection 9.3.5). These simple screening tests will provide an initial determination of the toxicity of potentially complex chemical mixtures in Woman Creek, the South Interceptor Ditch, and Ponds C-1 and C-2. If toxicity is observed in either the acute or chronic tests at any one station, then a supplemental toxicity testing program in conjunction with physical and chemical analyses of the water and sediment may be designed for that location to determine the potential extent of the toxicant(s).

Toxicity testing methods are available for terrestrial ecosystems using microbes, earthworms, crickets, and grasshoppers (U.S. EPA 1989c). The need for such tests will be evaluated based on the above criteria as part of this planning process.

Prior to conducting Task 9 studies, the field sampling plan will be refined to address the proposed methodologies. More specific DQOs will be formulated based on the proposed methodologies and will address the following:

- The number and types of analyses to be run
- The species, locations, and tissues to be sampled
- The number of samples to be taken
- The detection limits for contaminants
- The acceptable margin of error in analyzing results

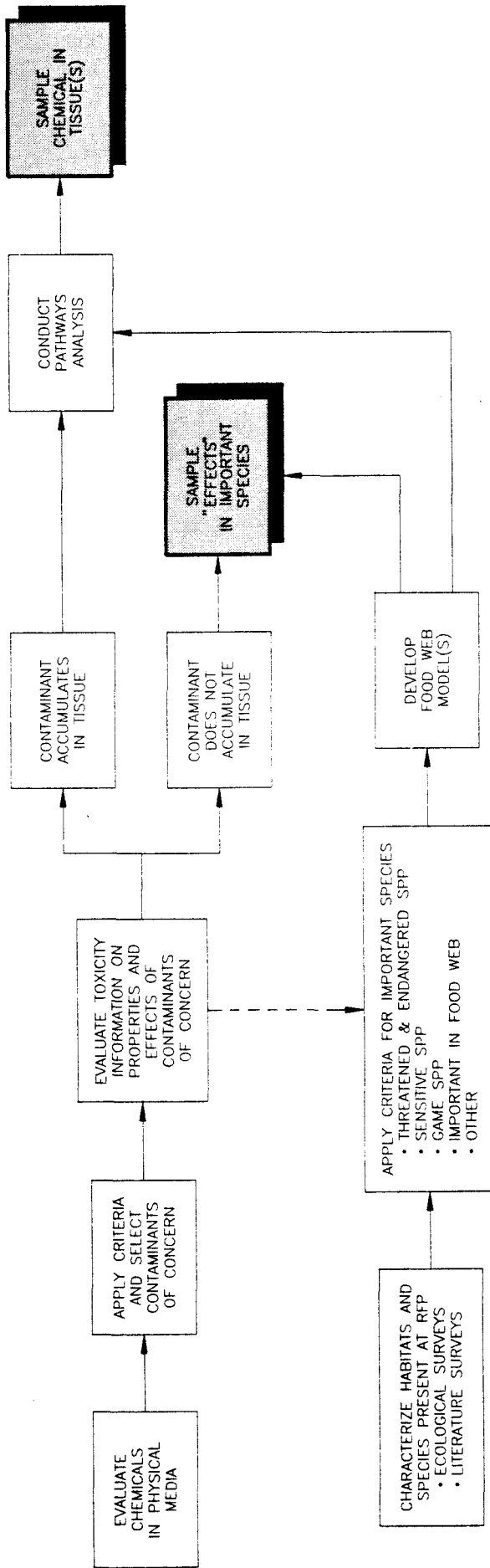
#### **9.2.10 Task 9: Ecotoxicological Field Investigations**

Tissue analyses will comprise most of the Task 9 ecotoxicological field investigation. Because individuals and species accumulate contaminants differentially in their tissues depending on the exposure route and form of the contaminants, environmental concentrations and general uptake rates will not necessarily predict biotic concentrations or adverse effects. Tissue analyses will be conducted to measure the total concentration of specific chemical compounds in key receptor species. By comparing tissue analysis results to toxicological benchmark concentrations (e.g., LC50 or MATC values), the potential for adverse effects in a population can be characterized. Analysis of tissue contaminant concentrations will provide data to confirm the predicted relationship, if any, between environmental concentrations and the amount of contaminants accumulated in receptor species.

Selection of the species and specific tissues for analysis will be based on a preliminary evaluation of site-specific food webs, potential contaminant transport pathways, and potential for bioaccumulation, bioconcentration, and biomagnification. The decision process for conducting tissue analyses is presented in Figure 9.3. Tissue sampling will only be conducted for those contaminants of concern which bioaccumulate in tissue. Whole bodies or specific tissues will be analyzed depending on which portion is consumed by higher trophic level organisms. Suitability of the species for sampling and sampling size requirements will largely determine the species to be selected for tissue analysis.

To the extent possible, tissue samples will be collected simultaneously with environmental media samples (see Section 7.0). This will allow for a determination of site-specific BCFs. These BCFs will be incorporated into the final exposure assessment and will be used to calibrate/validate the pathways model. Where BCFs cannot be determined, published or predicted BCF values will be used in the pathways model to assess potential impacts.

For contaminants of concern which bioaccumulate, the acceptable concentration (i.e., ARAR) in the physical environment (e.g., water) may be below reliable detection limits measurable by direct methods. For example, the chronic AWQC for protection of aquatic life for DDT is 1.9 nanograms per liter, while



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OPERABLE UNIT 5  
PHASE I RF/RI WORK PLAN

DECISION PROCESS FOR  
CHEMICAL SAMPLING  
OF TISSUES

FIGURE 9-3

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the detection level using gas chromatography is 0.1 micrograms per liter. In these instances, indicator species would be sampled as indirect indicators of contaminant concentrations in the physical media that bioaccumulate.

Where ARARs (i.e., acceptable levels in receptor species or next lowest prey species) are established, tissue sampling need only be conducted on site and not in the reference areas. Where no applicable ARARs exist, sampling for contaminants of concern would be conducted both on site and in appropriate reference area(s). The decision process on the use of reference areas for sampling contaminants in tissues is shown in Figure 9-4.

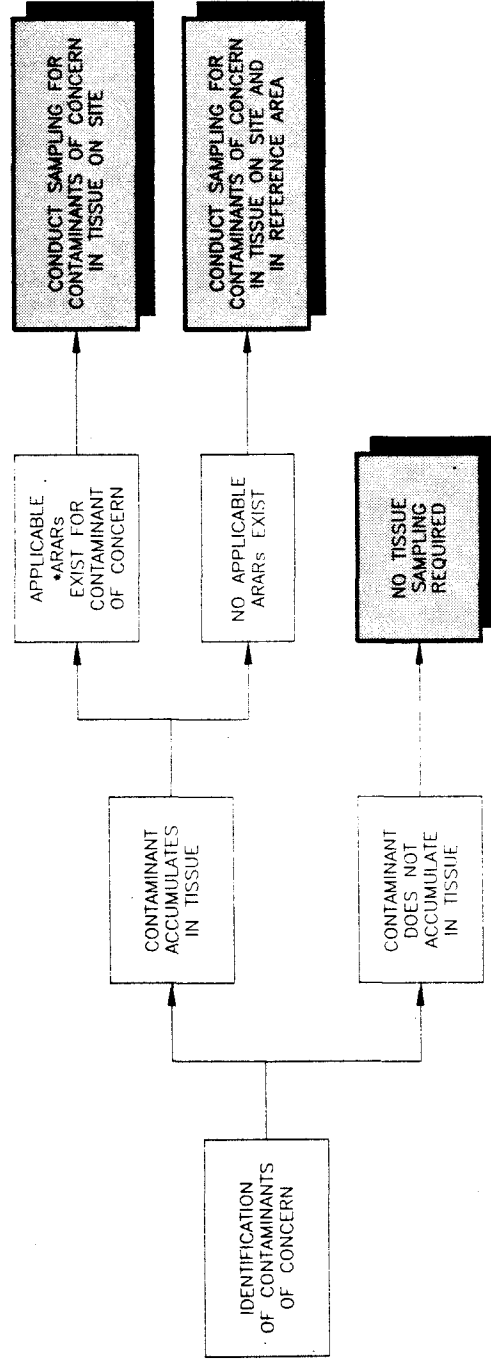
Statistical tests will be used in the measurement of the contaminant-specific biological response in samples from OU5 and the reference areas. Use of statistical tests will be consistent with DQOs and quality assurance provisions of the Quality Assurance Project Plan (QAPjP).

Additional ecotoxicological studies or toxicity tests may include in-situ (in-field) and/or laboratory toxicity tests. In-situ methods usually involve exposing animals in the field to existing aquatic or soil conditions. Laboratory toxicity tests can be used to evaluate the lethal or sublethal effects of chemicals as they occur in environmental media. Both approaches can be used to test for toxicity of mixtures as they actually occur in the environment. Selection of a particular methodology is generally based on the capability of the method to demonstrate a measurable biological response to the selected contaminant(s) of concern in addition to those specific criteria presented in Subsection 9.2.9.

#### **9.2.11 Task 10: Environmental Evaluation Report**

Task 10 will include the summary of information and production of an Environmental Evaluation Report as part of the RFI/FI Report. The Environmental Evaluation Report will be prepared in a clear and concise manner to present study results and interpretation. Relevant data from the environmental evaluation, in addition to relevant Phase I RFI/RI data, will be integrated and evaluated in the characterization of potential environmental impacts. The following topics will be covered in the report:

- Objectives
- Scope of Investigation
- Site Description
- Contaminants of Concern and Key Receptor Species
- Contaminant Sources and Releases
- Exposure Characterization
- Contamination (Impact) Characterization
- Remediation Criteria
- Conclusions and Limitations



- ARARs MAY NOT BE APPLICABLE IF THEY ARE BASED ON SPECIES THAT DO NOT EXIST ON SITE (e.g., TROUT), ARE BASED ON BIOTA PATHWAYS TO HUMANS, OR IF THEY ARE BELOW BACKGROUND FOR THE REGION (e.g., SOME METALS).

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PHASE I RFI/RI WORK PLAN

DECISION PROCESS ON USE  
OF REFERENCE AREAS FOR  
CONTAMINANTS IN TISSUES

A proposed, detailed outline of the report is shown in following Table 9-6.

### Remediation Criteria

The primary element used in the assessment of environmental effects or risk is a set of environmental criteria to which measured and or predicted concentrations of hazardous constituents in abiotic media are compared. Where these criteria are exceeded, adverse effects are likely to occur. Where water quality or other available federal or state criteria are available for comparison to concentrations of contaminants, they are generally used (see Section 9.2.7) (U.S. EPA 1989c). Remediation criteria can also be developed from other environmental statutes, such as the Toxic Substances Control Act or the Federal Insecticide, Fungicide and Rodenticide Act, or through the conduct of an environmental risk assessment such as outlined in this work plan.

Remediation criteria protective of biota are not available for contaminants in soils, or for many of the contaminants that occur in aquatic ecosystems at hazardous waste sites. Remediation criteria protective of site-specific plants and animals for the contaminants of concern can be developed in this environmental evaluation based on ecological effects criteria and detailed food-web analyses using a calibrated/validated pathways model. Ecological effects criteria are determined by tracing the biomagnification of contaminant residues from organisms at the top of the food web back through intermediate trophic levels to the abiotic environment. The "no effects" criteria levels for abiotic media are then derived from contaminant concentrations known to produce sublethal effects in the most sensitive (usually highest trophic level) organisms. Development of ecological effects criteria for OU5 will be based on results of the pathways model as well as available data which document potential adverse effects from contaminants of concern on key biological receptors. The process for establishing ecological criteria is shown in Figure 9-5. Determination of these criteria for OU5 will be coordinated with other RFI/RI studies and environmental evaluations.

The acceptable (no-effects) criteria levels will be used in conjunction with ARARs to evaluate potential adverse effects on biota as appropriate for the environmental evaluation portion of the Phase I RFI/RI. This approach will be integrated with the Human Health Risk Assessment process and will assist in the development of potential remediation criteria.

### **9.3 FIELD SAMPLING PLAN**

The OU5 Environmental Evaluation is planned in 10 tasks as described in Subsection 9.2. Field sampling activities will be conducted in Task 3 and Task 9 of the environmental evaluation. Task 3 will include brief field surveys, an ecological inventory of biota present at OU5, and initial aquatic toxicity testing. The field surveys and inventory will be conducted to obtain information on the occurrence,

**TABLE 9-6**  
**PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE**  
**FOR WOMAN CREEK DRAINAGE**

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**EXECUTIVE SUMMARY**

**1.0 INTRODUCTION**

- 1.1 OBJECTIVES
- 1.2 SITE HISTORY
- 1.3 SCOPE OF EVALUATION

**2.0 SITE DESCRIPTION**

- 2.1 PHYSICAL ENVIRONMENT
  - 2.1.1 Air Quality/Meteorology
  - 2.1.2 Soils
  - 2.1.3 Surface Water
  - 2.1.4 Groundwater
- 2.2 BIOTIC COMMUNITY
  - 2.2.1 Freshwater Community
  - 2.2.2 Terrestrial Community
  - 2.2.3 Protected/Important Species and Habitats

**3.0 CONTAMINANT SOURCES AND RELEASES**

- 3.1 SOURCES
- 3.2 RELEASES

**4.0 CONTAMINANTS OF CONCERN**

- 4.1 CRITERIA DEVELOPMENT FOR SELECTION OF CONTAMINANTS OF CONCERN
- 4.2 DEFINITION OF CONTAMINANTS

**5.0 TOXICITY ASSESSMENT**

- 5.1 TOXICITY ASSESSMENTS OF CONTAMINANTS OF CONCERN
- 5.2 CONTAMINANT EFFECTS
  - 5.2.1 Terrestrial Ecosystems
  - 5.2.2 Aquatic Ecosystems

**6.0 EXPOSURE ASSESSMENT**

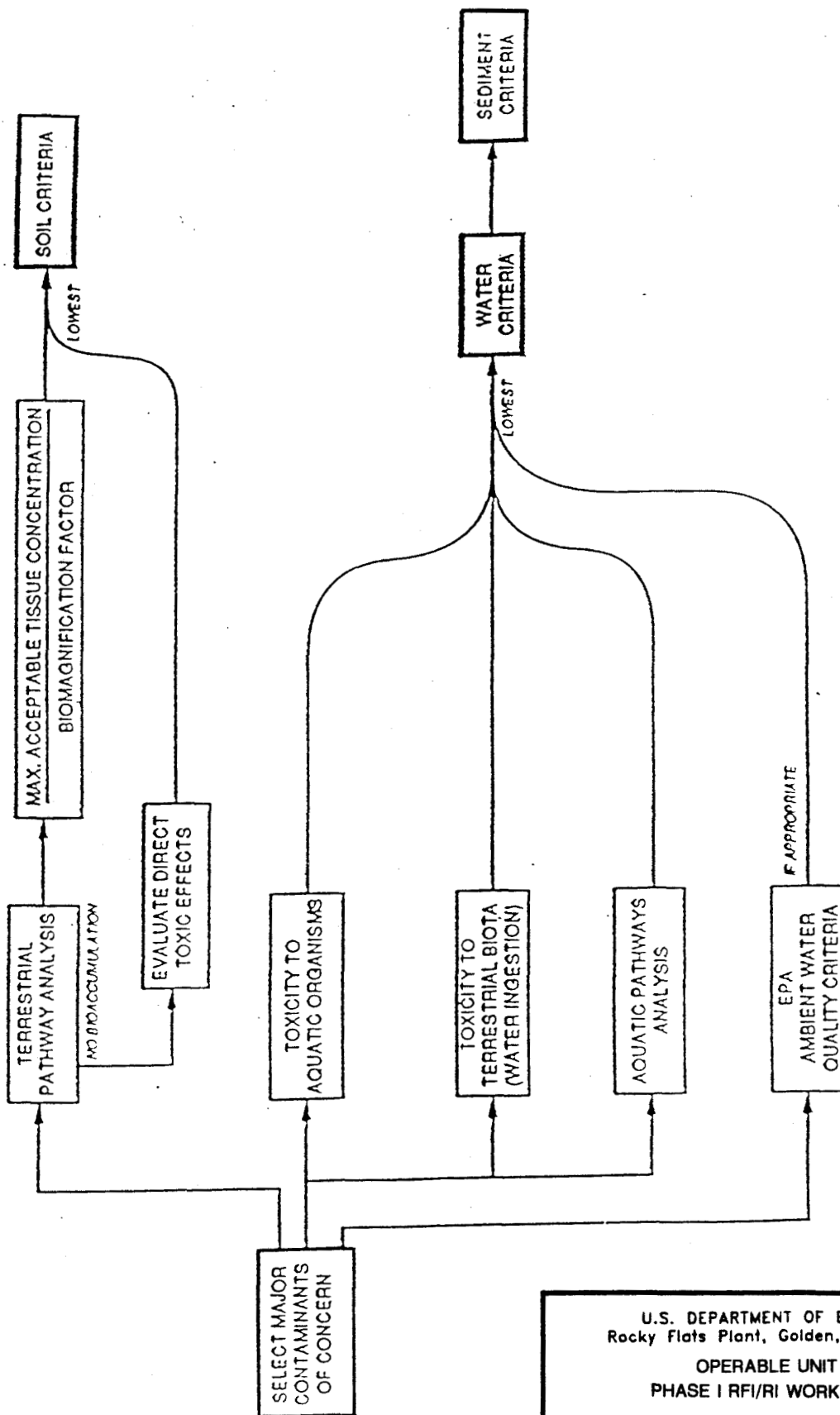
- 6.1 CONTAMINANT PATHWAYS AND ACCEPTABLE CRITERIA DEVELOPMENT
  - 6.1.1 General Methodology for Pathway Analysis
  - 6.1.2 Selection of Key Receptor Species
- 6.2 EXPOSURE POINT IDENTIFICATION
  - 6.2.1 Soil
  - 6.2.2 Water
  - 6.2.3 Vegetation

**TABLE 9-6**

**PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE  
FOR WOMAN CREEK DRAINAGE  
(Concluded)**

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- 6.3 CHEMICAL FATE AND TRANSPORT
- 6.4 EXPOSURE POINT CONCENTRATIONS
  - 6.4.1 Soil and Sediment Concentrations
  - 6.4.2 Surface Water Concentrations
  - 6.4.3 Groundwater Concentrations
  - 6.4.4 Vegetation Concentrations
- 6.5 EXPOSURE PATHWAYS
  - 6.5.1 Terrestrial Pathway
  - 6.5.2 Freshwater Pathway
- 7.0 CONTAMINATION CHARACTERIZATION
  - 7.1 DEVELOPMENT OF ECOLOGICAL EFFECTS CRITERIA
    - 7.1.1 Air Criteria
    - 7.1.2 Soil and Sediment Criteria
    - 7.1.3 Freshwater Criteria
    - 7.1.4 Vegetation Criteria
  - 7.2 EFFECTS CHARACTERIZATION
    - 7.2.1 Terrestrial Pathway
      - 7.2.1.1 Air
      - 7.2.1.2 Soil
      - 7.2.1.3 Vegetation
    - 7.2.2 Freshwater Pathway
      - 7.2.2.1 Air
      - 7.2.2.2 Surface Runoff
      - 7.2.2.3 Seeps and Springs
- 8.0 ASSUMPTIONS AND UNCERTAINTIES
- 9.0 RECOMMENDATIONS AND CONCLUSIONS
- 10.0 REFERENCES



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OUTLINE OF THE METHODOLOGY  
FOR DETERMINING CRITERIA FOR  
MAJOR CONTAMINANTS OF CONCERN

distribution, and general abundance of biota in OU5. Data obtained in the field inventory will be used to identify key receptor species, to develop a site-specific food web model and to provide input to the pathways analysis and contamination assessment. Planning for the Task 9 tissue analysis program will begin in Task 2 so that samples collected in the Task 3 field inventory may be used wherever possible (i.e., where contaminants of concern have been defined and field sampling protocol have been developed). Final determination of the need for further ecotoxicological studies in Task 9 will be made in Task 8, Planning, after completion of the contamination assessment.

The following field sampling plan is provisional and will be periodically revised as appropriate. The Task 3 sampling plan is largely complete but may be altered in order to better coordinate with the surface water and soil sampling programs for OU5 or other operable units. The Task 9 field sampling plan will be designed in greater detail after contaminants of concern and key receptor species have been identified and a preliminary determination of food webs and contaminant source-receptor pathways has been developed. This information will allow determination as to which contaminants of concern are likely to be present in sufficient concentrations to be detected in biota and which biota are most practical and suitable for sampling.

SOPs for sampling biota as part of the Environmental Evaluation process at Rocky Flats are currently in publication. The SOPs will include discussion of purpose and scope, responsibilities and qualifications, references, equipment, and execution of protocols. Sampling procedures for the following organisms will be included in the forthcoming document:

- Periphyton
- Benthic macroinvertebrates
- Plankton
- Fishes
- Large mammals
- Small mammals
- Birds
- Reptiles and amphibians
- Terrestrial arthropods
- Terrestrial vegetation
- Soil microbes

SOPs that are currently being developed in addition to the above include the following:

- Design of Field Sampling Plans
- Selection of Reference Areas
- Recording and Managing Data

- Preserving and Handling Samples
- Conducting Laboratory Studies
- Incorporating QA/QC

The preceding SOPS are referenced in the following OU5 Field Sampling Plan where appropriate.

### 9.3.1 Sampling Objectives

The Task 3 Ecological Field Investigation for OU5 has four broad objectives:

1. Conduct brief field surveys and an ecological inventory to describe the existing ecological setting in terms of habitats, vegetation, wildlife and aquatic species. Conduct initial aquatic toxicity testing using Ceriodaphnia spp. and fathead minnows. Observe OU5 for obvious signs or zones of contamination or injury to biota and their habitats. Accomplish ecological field inventory, through the use of established ecological field methodologies (e.g., Mueller-Dombois and Ellenberg 1974; Southwood 1978; Krebs 1989).
2. From the above data, identify key food web species which represent the major flow of energy and nutrients and thus the major pathways for contaminant transfer from physical environmental media to higher trophic-level ecological receptors.
3. Identify the presence or absence of protected or other important species and habitats.
4. Provide site-specific information for determining objectives, measurement endpoints and methodologies for Task 9 field/laboratory contamination studies.

Data from the field survey, inventory and aquatic toxicity tests will be summarized, tabulated and accompanied with a narrative description of the following data types:

- Species Present (Diversity)
- Habitat Descriptions/ Mapping Units (Clark et al. 1980)
- Soil Descriptions/ Classifications (part of RFI effort)
- Critical/ Protected Habitats
- Protected Species
- Terrestrial and Aquatic Food Webs
- Potential Exposure Pathways
- Abundance of Key Species
- Vegetation Cover

- Vegetation Frequency and Density (shrubs/trees)
- Vegetation Importance (community dominance) Values
- Aquatic Toxicity Test Results

Appropriate statistical tests will be used to analyze the data so that precision and accuracy of the results can be presented at a stated level of confidence. Depending on the data types being analyzed, within-and-between station differences, within-and-between season differences, and within-and-between species differences will be presented. Means, variances, standard errors, analyses of variance, regression, and correlation coefficients will be computed as appropriate. Where sample sizes are insufficient to detect differences, only descriptive statistics will be prepared.

### **9.3.2 Sample Location and Frequency**

Both Task 3 and Task 9 field sampling activities for OU5 will be located and timed to the extent possible to coincide with collection of other media samples (soils, surface water, and groundwater) as well as sampling activities at other operable units. This integrated sampling approach is consistent with EPA guidance and will provide a synoptic view of potential contaminants in all relevant media at one time.

The field sampling plan for Task 3 is based on the assumption that brief field surveys will be conducted in the spring, summer, fall and winter and that the ecological field sampling program will take place within the May-June and July-August timeframes. Aquatic toxicity testing will take place in May-June (high flow) and September-October (low flow). Information from the initial surveys and field inventory may be used to modify sampling parameters for later field investigations.

Sampling locations are largely located at or downgradient from areas of known or suspected contamination. Sampling locations were selected to coincide with sampling efforts in abiotic media and to characterize the biotic communities that are present. The intent of the selected locations was not to test specific hypotheses regarding the effects of contamination, but to characterize the ecological communities that are present and provide site-specific input to the pathways model.

#### **9.3.2.1 Locations for Vegetative Sampling**

Vegetation sampling for phytosociological data will be performed at OU5 IHSSs, at the Surface Disturbance south of the Ash Pits, along the South Interceptor Ditch, and along Woman Creek. A systematic walk-through of these areas will be conducted in the spring, summer, and fall to observe species composition.

A stratified randomization procedure will be utilized to identify sampling locations for the quantitative vegetative description portion of the field inventory. The basis for selecting a random procedure of

vegetation transect/plot location is to obtain as unbiased an estimator as possible of true population parameters for herbaceous cover and shrub/tree density and frequency. Stratification is required because several distinct vegetation types appear to be present in the study area, including prairie grassland, marsh, streambank vegetation, well-vegetated disturbed areas, and sparsely vegetated disturbed areas.

The basis for stratification will be a vegetation type map, to be prepared based on the 1975 University of Colorado vegetation map of Rocky Flats and the Clark et al. (1980) report, updated by visual observations during the field surveys. This map will cover Woman Creek Drainage.

Transects for the quantitative community surveys will be located near soil sampling sites (see Subsection 7.2) wherever possible. From each soil sampling point, the centerpoint of a vegetation transect will be selected based on a random distance (to 10 m) and random direction, using random numbers tables. Transect locations will be selected until an adequate number has been selected for each major vegetation type at each IHSS. Locations will be discarded under several conditions: where the selected location is in a vegetation type for which an adequate number of transects has already been selected (for each IHSS); where the vegetation is not homogeneous (i.e., located in more than one type or across an ecotone); and where the transect would be located in buildings or paved areas. A similar process will be used for transects along Woman Creek and the South Interceptor Ditch, where the sample locations will be located in the general area of the surface-water/sediment sampling points. Since vegetation types associated with these features tend to be linear, the randomization process may require limits on direction. Multiple transects will be located near (within 50 meters of) each surface water/sediment sampling point to provide an adequate sample size.

#### **9.3.2.2 Locations for Periphyton, Macroinvertebrates and Fish Sampling**

Periphyton, macroinvertebrates and fish samples will be collected at the following surface water sampling locations: SW-26, SW-31, SW-32, SW-36, SW-39, SW-46, SW-70, SW-126, Pond C-1, and Pond C-2 (Figure 9-6). Should the organisms or proper habitat be absent at a particular location, then the nearest location downstream with suitable habitat will be sampled and located on a map. Sampling at OU5 will be coordinated with OU5 surface water and sediment sampling activities as well with OU1 and OU2 sampling programs. Both sediment and surface water quality data will be collected at the same locations and time as the aquatic biota sampling. Sampling locations may be altered to ensure these efforts are coordinated. Sampling locations for aquatic biota may also be altered depending on DQOs or required sample size.

#### **9.3.2.3 Locations for Wildlife Sampling**

A terrestrial wildlife inventory will be conducted within OU5 and along Woman Creek and the South Interceptor Ditch. Small mammal sampling will be conducted, to the extent possible, at the vegetative sampling locations. Searches for reptiles will be conducted in appropriate habitats in OU5.

#### **9.3.2.4 Locations for Initial Toxicity Testing**

Locations for initial aquatic toxicity testing will be mostly the same as those for periphyton, macrobenthos and fish sampling: SW-26, SW-31, SW-32, SW-36, SW-39, SW-46, SW-67, SW-70, SW-126, Pond C-1, and Pond C-2 (Figure 9-6). Toxicity testing activities for OU5 will be coordinated with toxicity testing activities proposed for OU2 and OU1 as part of the implementation of the field sampling effort.

#### **9.3.2.5 Tissue Sampling Locations**

Locations for the collection of tissue samples (terrestrial vegetation, periphyton, benthos, macrobenthos, fish) will be the same as those for terrestrial and aquatic sampling. An initial identification of species for tissue sampling will be made in Task 2. Additional sampling requirements will be determined during the contamination assessment (Tasks 4 through 7) and contaminant data from surface water, soil and sediment sampling. The intent is to collect tissue samples where existing abiotic media sampling has indicated significant contamination to occur. Development of the OU5 tissue sampling program will be coordinated with OU1 and OU2 programs.

#### **9.3.2.6 Sample Frequency**

Brief field surveys will be conducted during 1-week periods in the spring, summer, fall, and winter. Special note of transitory species, migratory species, and seasonal breeding habits will be made during these multi-season surveys.

Field inventory sampling will occur during the May-June and July-August timeframes. Samples collected during the inventory will be saved and used in the tissue analysis studies where sampling and analysis protocol have been established.

Initial toxicity tests will also be conducted during May-June (high flow) and September-October (low flow). Two acute and two chronic tests will be conducted within 1 to 2 weeks of each other during each season. If toxicity is observed in either acute or chronic tests at any one station, then a supplemental

program will be designed for that location to determine if the toxicity is consistent and to determine the potential extent of the toxicant.

### **9.3.3 Reference Areas**

Tissue analysis studies may require the sampling of contaminated and control areas in order to establish a relationship between contaminated conditions and background conditions in areas not exposed to Rocky Flats Plant contamination. Selection of reference areas may be based on criteria developed in the Task 1 preliminary planning process and may be coordinated with similar efforts at other operable units. Potential selection criteria include species to be sampled or similarity to OU5 in terms of topography, aspect, soils, vegetation, range type and land use history. Reference areas should be upwind from prevailing air flow patterns through Rocky Flats Plant and upstream from drainage off Rocky Flats Plant.

SOPs for sampling biota as part of the environmental evaluation process at Rocky Flats are currently in publication. Additional aquatic reference areas ideally should be located in Rock Creek. A site visit will be made of the proposed aquatic sampling locations for OU5, OU1, and OU2. Habitat characteristics will be noted if not previously recorded in ongoing Rocky Flats Plant studies (depth, flow, substrate type, pool/riffle, aquatic/streamside vegetation, etc.). This process will be repeated at potential reference sites.

Reference areas would be selected only after criteria, data quality objectives, and measurement endpoints are identified. The process for selected reference areas will be initiated in Task 1.

### **9.3.4 Field Survey and Inventory Sampling Methods**

Sampling methods for periphyton, benthic macroinvertebrates, fishes, mammals, birds, reptiles and amphibians, terrestrial arthropods, and terrestrial vegetation are detailed in the Ecology SOPs. The SOPs include several standardized forms to be used when sampling biota. Site Description Form 5.0D will be used for sampling terrestrial biota; stream and pond habitat description forms (Forms 5.0A and 5.0B) will be completed at each of the aquatic sampling locations. Chain-of-custody field sample forms will be completed where samples are collected for laboratory analysis or voucher specimens. Additional forms to be completed are specified in the following subsections.

#### **9.3.4.1 Vegetation**

Both qualitative and quantitative methods will be used to characterize the terrestrial and wetland vegetation at OU5. Qualitative surveys using a relevé analysis (see Ecology SOPs) will be conducted in the spring, summer, and fall to record the floristic composition of the plant communities present.

These qualitative surveys will include a systematic walk-through of the IHSSs, Woman Creek, and the South Interceptor Ditch. The following data will be recorded on all vegetation species encountered:

- Scientific name
- Common name
- Life form
- Vegetative stage at the time
- Qualitative statement on condition
- Qualitative statement on abundance (relevé analysis - see Ecology SOPs)

Quantitative procedures will be used to collect structural and compositional data. Point-intercept transects will be used to collect data on species cover. Data will be recorded on Form 5.10B, Point-Intercept Data Form. Belt transects will be used in conjunction with the point-intercept transects to collect data on shrub cover and density. Trunk diameter, height, canopy diameter, and species will be recorded for any trees within the belt transect or within any IHSS. Shrub and tree data will be recorded on Form 5.10C, Belt Transect Data Form. Production data (standing biomass) will be collected from 1/4- to 1-m<sup>2</sup> quadrants at the same locations as the transects. Different quadrant sizes may be used depending on vegetation type (e.g., a 1/4-m<sup>2</sup> quadrant may be used on dense streambank vegetation). Production data will be recorded on Form 5.10D.

Each plot or 10-meter transect will be considered as an observation in calculating the mean and variance. Sample adequacy will be determined for total herbaceous cover and total fresh weight biomass using Cochran's formula (1977):

$$N = \frac{(t^2)(s^2)}{[(\bar{x})(d)]^2}$$

where: N = the minimum number of samples needed  
t = t distribution value for a given level of confidence  
s<sup>2</sup> = the variance estimate  
x = the mean of the sample  
d = the level of accuracy desired

#### **9.3.4.2 Terrestrial Wildlife and Invertebrates**

The Task 3 survey is planned to note the presence or absence of terrestrial/wetland species and to make note of their food habits. The survey procedure will include a systematic walk-through of OU5 area, including the South Interceptor Ditch and Woman Creek to record ecological features. Field data will be recorded on the standardized Qualitative Survey/Relative Abundance Data Form 5.0C for large mammals, small mammals, birds, reptiles and amphibians, and terrestrial arthropods. Opportunistic

observations of bird and raptor nests, large mammal pellets and mammal burrow/dens will be recorded on the appropriate forms. Vocalization surveys for birds and anurans will also use the appropriate forms. Data to be recorded include:

- Species encountered/ observed
- Scientific name
- Common name
- Qualitative statement on:
  - Condition
  - Abundance
  - Habitat requirements
  - Predator/prey species/food habits
  - Regulatory status (to be determined prior to field sampling)
- Species presence will be determined by:
  - Visual observation
  - Vocalization
  - Burrow/den
  - Nest
  - Droppings/scat

Quantitative information on wildlife populations will be obtained in the Task 3 field inventory. Inventory sampling will include the following procedures, which are detailed in the SOPs:

- Live trapping of small mammals on the adjacent hillsides and along the South Interceptor Ditch and Woman Creek. Data to be recorded include:
  - Scientific name/common name
  - Sex
  - Reproductive condition
  - Weight
  - Life history stage

- Reptile occurrence will be recorded along the same transects used for small mammal trapping in addition to habitat searches. Data to be recorded include:
  - Species encountered
  - Activity
  - Habitat
  - Qualitative statement on abundance
- Medium- and larger-sized mammals will be counted by recording all species along a systematic walk-through of OU5 including the South Interceptor Ditch and Woman Creek. The counting will occur during the small mammal transect trapping. Species encountered and activity will be recorded.
- Foliage invertebrates will be collected by sweep net and beating. Where conditions permit, foliage invertebrate and arthropod sampling may be conducted using a D-vac suction sampler in place of sweep netting (see Ecology SOPs). Data to be recorded will include:
  - Host plant
  - Herbivore
  - Position in food web

#### **9.3.4.3 Periphyton**

Sampling to characterize periphyton communities will occur at the selected locations along Woman Creek, the South Interceptor Ditch and Ponds C-1 and C-2 (see SOP). Triplicate samples will be taken on a transect upstream and within 10 meters of the designated sampling locations. Data to be collected include:

- Scientific name
- Algal density (cell counts of each taxon)
- Biomass (chlorophyll-a and phaeophytin-a concentrations)

Field data will be recorded on the Periphyton Field Sample Form 5.1A (see SOP). Data from quantitative sampling will be used to determine species diversity and standing crop (biomass). All analyses will be completed within five days of the collection of the slides from the field (U.S. EPA 1987b).

#### 9.3.4.4 Macrobenthos

Benthic invertebrates are the most common fauna used in ecological assessments of contaminant releases and are defined as the invertebrates retained by screens of mesh size greater than 0.2 mm. Macrobenthos will be sampled at the aquatic sampling locations shown in Figure 9-3 using the procedures described in the SOPs. Triplicate samples will be taken on a transect upstream and within 10 meters of the designated sampling locations. Data to be collected include:

- Scientific name (generally to genus)
- Number of individuals in each taxon

Field data will be recorded on the benthic macroinvertebrate field sample Form 5.2A. Data from quantitative samples will be used to determine macroinvertebrate density (standing crop), taxa richness, and taxa diversity.

#### 9.3.4.5 Fish

Fish will be collected in 10- to 25-meter-long collection areas using a backpack shocker or by seining blocked-off creek sections. In Ponds C-1 and C-2, fish will be sampled from a flat-bottom boat using an electroshocker. Data to be collected include:

- Scientific name
- Number of individuals in each taxon
- Length
- Weight

Scales will be collected to obtain data on age classes versus size, population structure and survivorship. Field data will be recorded on the Fish Field Inventory Form 5.4B (see SOP). Samples will be taken for laboratory identification/ confirmation. Analyses will consist of compiling and summarizing the number, size, and weight of each species of fish captured at each sampling site. Graphic presentations may include fish length-frequency histograms and plots of catch-per-effort for each sampling area.

### 9.3.5 Initial Toxicity Tests

The initial toxicity testing program will be limited to aquatic organisms and will include standardized EPA acute and chronic tests with fathead minnows and Ceriodaphnia spp. Water samples will be cooled to 4°C and shipped to the laboratory conducting the toxicity tests within 12 to 24 hours. The toxicity tests will be initiated within 36 hours of the field collection time. The duration of the static renewal acute tests will be 48 hours for Ceriodaphnia spp. and 96 hours for fathead minnows. The test water will be

renewed daily using dilution water from the sampling station. The static renewal chronic tests will last for 7 days for fathead minnows and until 60 percent of the Ceriodaphnia spp. in the control vessels have three broods. Quality control procedures will conform to the EPA requirements for NPDES toxicity testing currently being used at Rocky Flats and to the QAPjP.

#### **9.3.6 Tissue Analysis Sampling Methods**

The methodologies selected for tissue analysis studies will depend on the contaminants of concern and their anticipated effects on the selected key receptor species. Contaminants of concern and key receptor species will be determined as early as possible in Task 2. It is anticipated that some biota samples collected in the Task 3 field inventory can be used for tissue analysis. Standardized site protocol for preserving samples for tissue analyses will be followed in those instances where it is anticipated that tissue analyses will be conducted.

Analyses for metals and radionuclides in biota may call for a greater biomass of tissue than is available through standard collection methods. At least 80 grams of material (wet weight) is needed per sample for metals analysis, and 100 grams of material (dried and ashed) is needed for radionuclides. Obtaining this amount of sample may be impractical for some species of vegetation, periphyton, and macrobenthos. It is also not the intent of the sampling program to cause unnecessary disturbance or damage to the biota communities in order to collect sufficient samples. Sampling design will be adequate to ensure statistically valid results. DQOs for the tissue sampling program will be evaluated with respect to this determination prior to field collection activities.

Based on the literature reviewed and the information presented in this report, it is anticipated that most tissue samples will be analyzed for metals and very few samples, if any, may be analyzed for radionuclides. Tissue samples collected for contaminant analysis will be sent to a laboratory for specific metals and radionuclide analyses as determined in the preliminary Task 1/Task 2 environmental evaluation. Analytical methods will follow SOPs.

Holding times, preservation methods, sample containers, and field and laboratory quality control sample numbers are contained in the Quality Assurance Project Plan (QAPjP) and shown in Table 9-7. Tissue sampling protocol for biota are not necessarily standardized and may vary depending upon the laboratory conducting the analyses. Specific sample preparation requirements will be reported in SOPs which are currently in development.

#### **9.3.7 Sampling Equipment**

Equipment for field sampling of biota are identified in the Volume V Ecology SOPs.

TABLE 9-7

## HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

|                                                         | Holding Time From<br>Date Collected | Preservation<br>Method      | Container                                         | Approximate<br>Sample Size <sup>++</sup> |
|---------------------------------------------------------|-------------------------------------|-----------------------------|---------------------------------------------------|------------------------------------------|
| <b>SAMPLES FOR METALS ANALYSES</b>                      |                                     |                             |                                                   |                                          |
| <u>Terrestrial Vegetation</u>                           |                                     |                             |                                                   |                                          |
| - Metals Determined by ICP**                            | 6 mos                               | Freeze & ship w/ dry<br>ice | Paper bag inserted into<br>plastic bag and sealed | 25 g                                     |
| - Metals Determined by GFAA +                           | 6 mos.                              | Freeze & ship w/ dry<br>ice | Paper bag inserted into<br>plastic bag and sealed | 25 g                                     |
| - Hexavalent Chromium                                   | 24 hours                            | Freeze & ship w/ dry<br>ice | Paper bag inserted into<br>plastic bag and sealed | 25 g                                     |
| - Mercury                                               | 28 days                             | Freeze & ship w/ dry<br>ice | Paper bag inserted into<br>plastic bag and sealed | 5 g                                      |
| <u>Periphyton, Benthic<br/>Macroinvertebrates, Fish</u> |                                     |                             |                                                   |                                          |
| - Metals Determined by ICP                              | 6 mos.                              | Freeze & ship w/ dry<br>ice | Plastic                                           | 25 g                                     |
| - Metals Determined by GFAA                             | 6 mos                               | Freeze & ship w/ dry<br>ice | Plastic                                           | 25 g                                     |
| - Hexavalent Chromium                                   | 24 hours                            | Freeze & ship w/ dry<br>ice | Plastic                                           | 25 g                                     |
| - Mercury                                               | 28 days                             | Freeze & ship w/ dry<br>ice | Plastic                                           | 5 g                                      |

TABLE 9-7  
(Concluded)

| SAMPLES FOR RADIONUCLIDE ANALYSES                                  |                                     |                             |                                                   |                               |
|--------------------------------------------------------------------|-------------------------------------|-----------------------------|---------------------------------------------------|-------------------------------|
|                                                                    | Holding Time From<br>Date Collected | Preservation<br>Method      | Container                                         | Approximate<br>Sample Size ++ |
| <u>Terrestrial Vegetation</u>                                      |                                     |                             |                                                   |                               |
| - Uranium-233, 234, 235, 238<br>Americium-241<br>Plutonium-239/240 | 6 mos                               | Freeze & ship w/ dry<br>ice | Paper bag inserted into<br>plastic bag and sealed | 100 g                         |
| <u>Periphyton, Benthic<br/>Macroinvertebrates, Fish</u>            |                                     |                             |                                                   |                               |
| - Uranium-233, 234, 245, 238<br>Americium-241<br>Plutonium-239/240 | 6 mos                               | Freeze & ship w/ dry<br>ice | Plastic                                           | 100 g                         |

\*\*ICP = Inductively Coupled Argon Plasma Emission Spectroscopy. Metals to be determined include Ba, Cr, Cu, and Fe.

+ GFAA = Graphite Furnace Atomic Absorption Spectroscopy. Metals to be determined include As, Cd, Li, Pb, Se, and Sr.

++ Sample size may vary with specific laboratory requirements.

#### 9.4 SCHEDULE

The following Figure 9-7 presents a proposed schedule for implementation of the OU5 environmental evaluation. The schedule follows the task approach presented in this environmental evaluation. While many of the tasks are sequential, most tasks will overlap in time. The months indicated in the table reflect the timeframe in which the activity will occur and not necessarily the amount of time necessary to complete the task. The schedule is provisional and likely to change depending on the Phase I OU5 RFI/RI activity schedule as well as schedules from other operable units.

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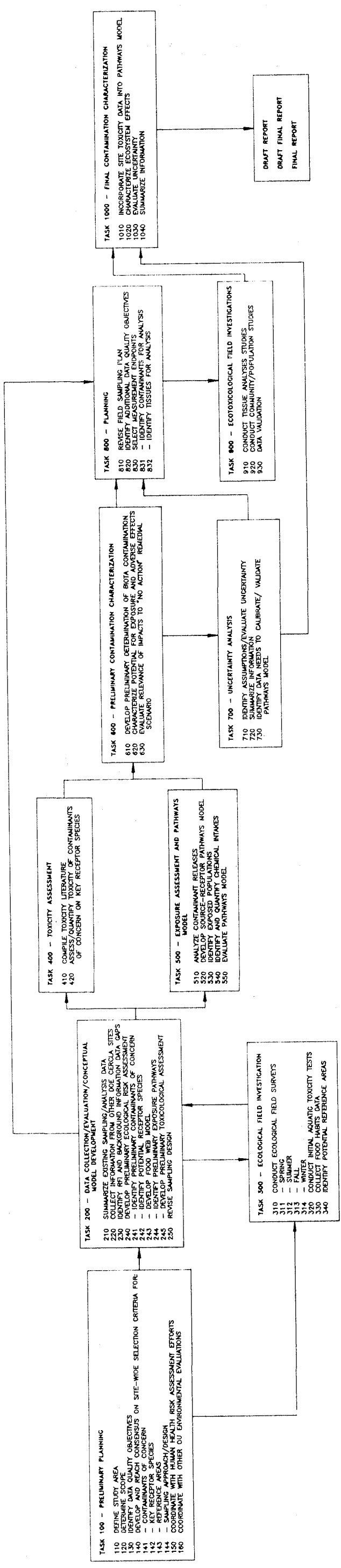
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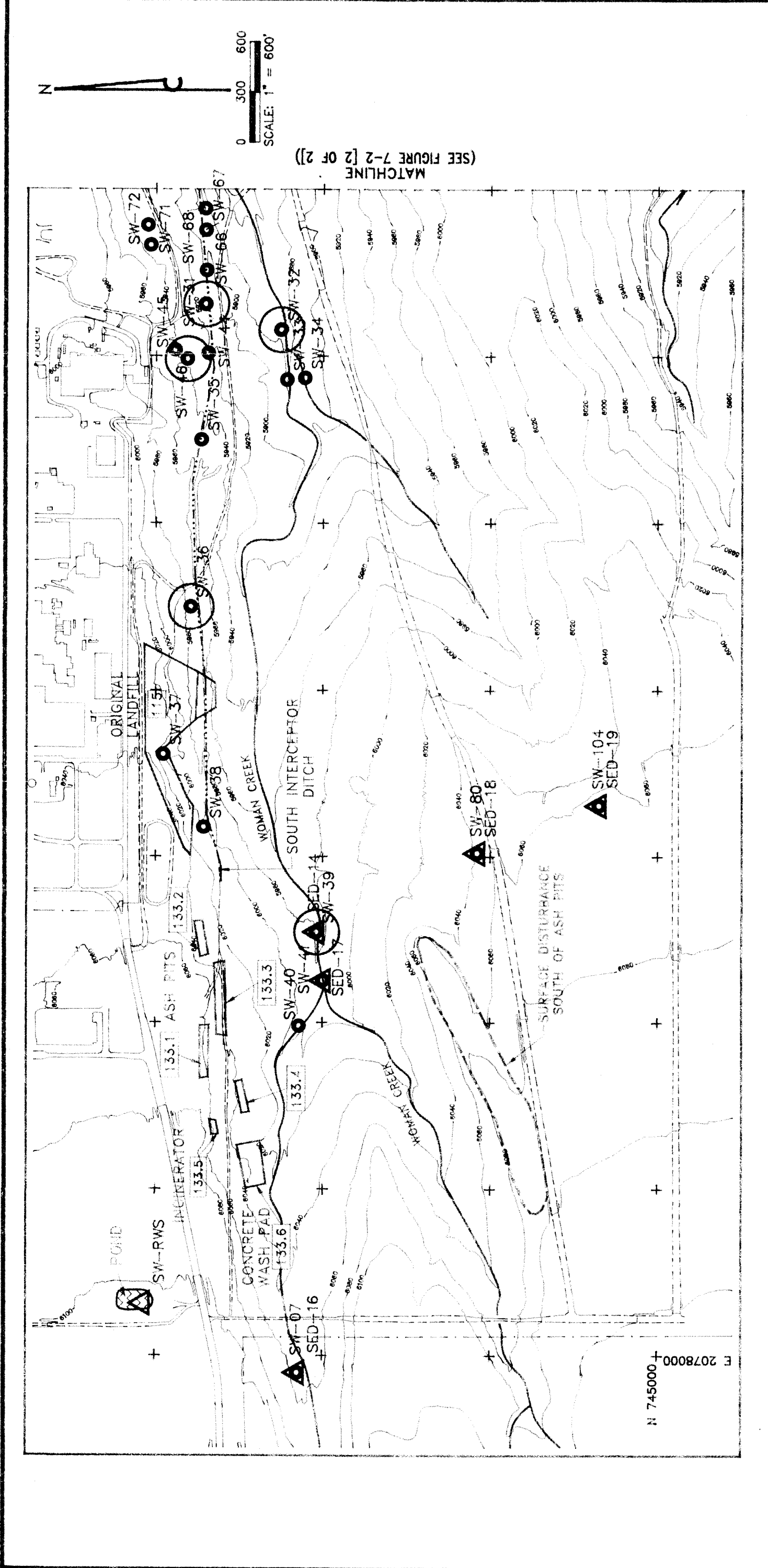


U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 5  
PHASE I RFI/RI WORK PLAN

FLOW DIAGRAM:  
INTERRELATIONSHIPS BETWEEN TASKS

FIGURE 9-1 MAY 1991



MATCHLINE  
(SEE FIGURE 7-2 [2 OF 2])

### EXPLANATION

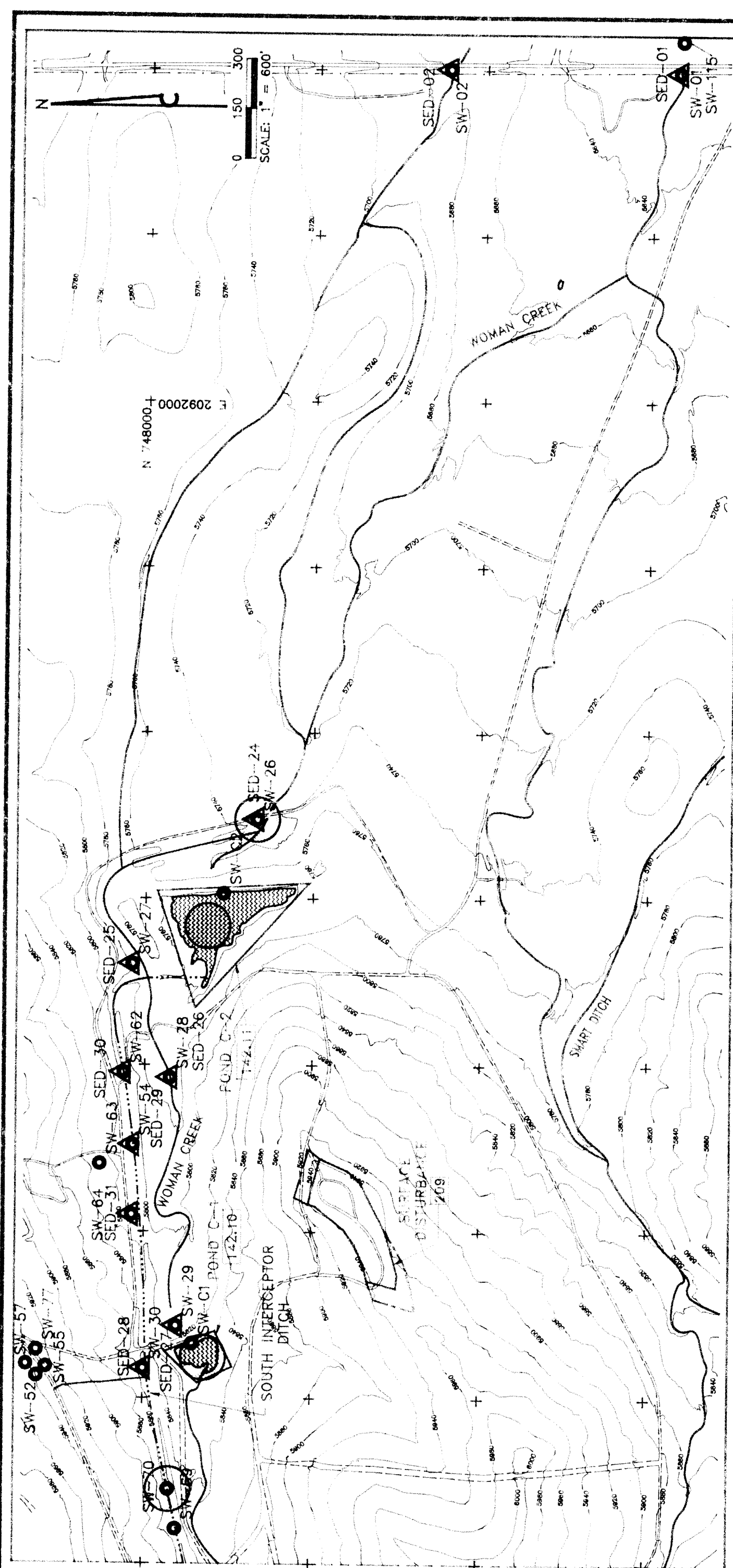
- 115 INDIVIDUAL HAZARDOUS SUBSTANCE SITE
- SW-1 ● EXISTING SURFACE WATER LOCATION
- SED-1 ▲ EXISTING SEDIMENT SAMPLING LOCATION
- SOUTH INTERCEPTOR DITCH
- DIRT ROAD
- PRELIMINARY EXTENSION OF THE SURFACE DISTURBANCE BASED ON A RECONNAISSANCE

U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado  
OPERABLE UNIT 5  
PHASE 1 RFI/RI WORK PLAN

### LOCATION MAP OF THE INDIVIDUAL HAZARDOUS SUBSTANCE SITES AND AQUATIC SAMPLING LOCATIONS

FIGURE 9-6 (1 OF 2)

MAY 1991



MATCHLINE  
(SEE FIGURE 7-2 [1 OF 2])

### EXPLANATION

- 115 INDIVIDUAL HAZARDOUS SUBSTANCE SITE
- SW-1 EXISTING SURFACE WATER LOCATION
- SED-1 EXISTING SEDIMENT SAMPLING LOCATION
- INTERMITTENT STREAM
- DIRT ROAD
- SAMPLING LOCATIONS FOR AQUATIC BIOTA
- PRELIMINARY EXTENSION OF THE SURFACE DISTURBANCE BASED ON A RECONNAISSANCE

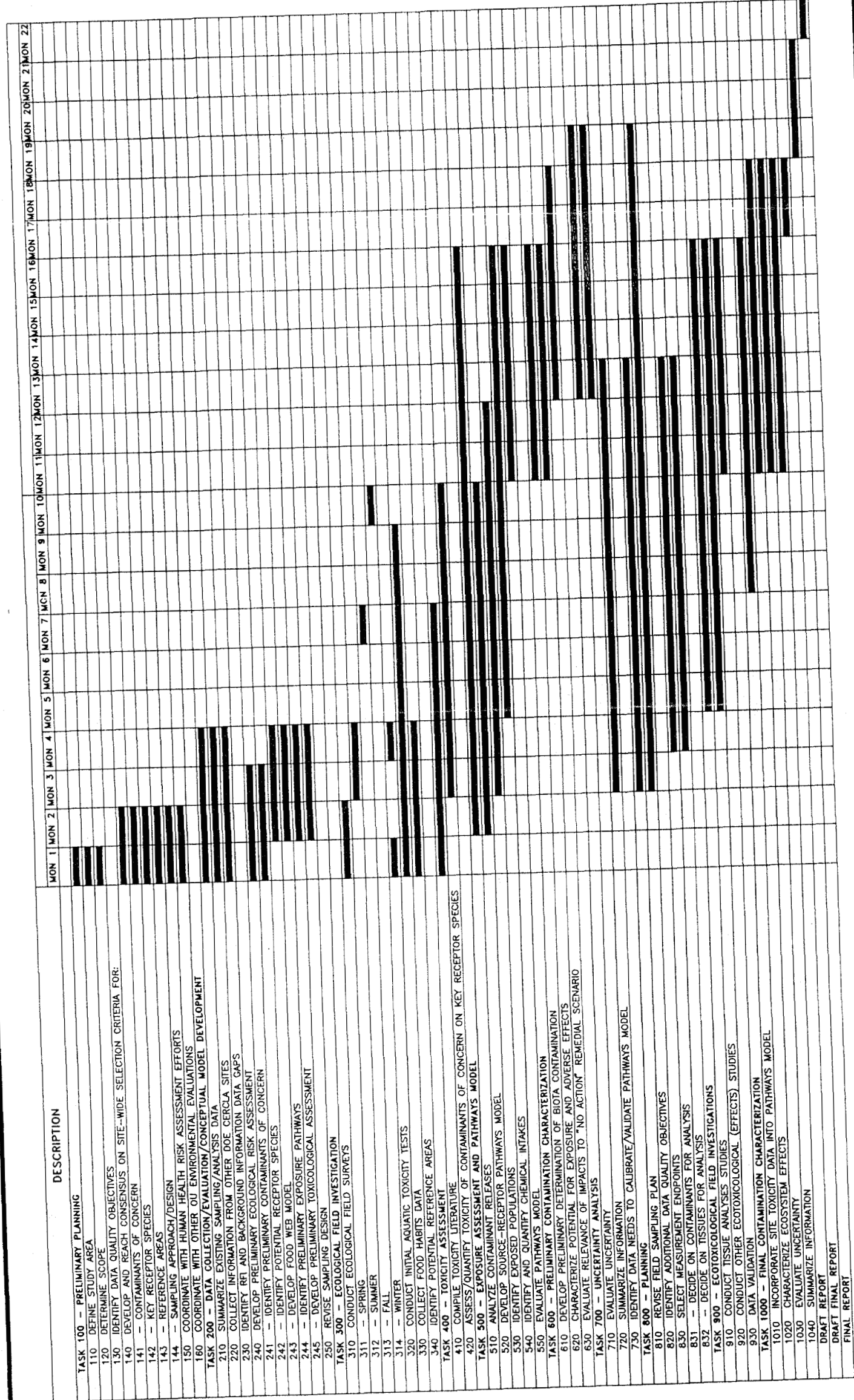
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OPERABLE UNIT 5  
PHASE 1 RFI/RI WORK PLAN

LOCATION MAP OF THE INDIVIDUAL  
HAZARDOUS SUBSTANCE SITES AND  
AQUATIC SAMPLING LOCATIONS

FIGURE 9-6 (2 OF 2)

MAY 1991



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OPERABLE UNIT 5  
 PHASE I RF/RI WORK PLAN

WOMAN CREEK DRAINAGE  
 ENVIRONMENTAL EVALUATION  
 ACTIVITY SCHEDULE

FIGURE 9-7

MAY 1991